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AN ANALYSIS OF THE MAINTENANCE PERFORMANCE MEASUREMENT SYSTEM FOR LAMPS MK III HELICOPTER SQUADRONS

by

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ABSTRACT *(maximum 200 words)*

With the current downsizing of the United States military and the defense budget, the diminishing availability of resources has increased the focus on the need for effective management. This thesis discusses several factors affecting performance improvement (effectiveness, efficiency, quality, productivity, budgetability, quality of work life, and innovation) for LAMPS MK III helicopter squadrons. Current non-financial measures for monitoring the performance of maintenance are examined and evaluated. Alternative maintenance performance measures are described and discussed. The alternative measures for which source data is available are analyzed. A new performance measurement model, the Multi-Criteria Performance/Productivity Measurement Technique, and the Objectives Matrix, is described and recommended for measuring LAMPS MK III helicopter squadron maintenance performance.

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ABSTRACT

With the current downsizing of the United States military and the defense budget, the diminishing availability of resources has increased the focus on the need for effective management. This thesis discusses several factors affecting performance improvement (effectiveness, efficiency, quality, productivity, budgetability, quality of work life, and innovation) for LAMPS MK III helicopter squadrons. Current non-financial measures for monitoring the performance of maintenance are examined and evaluated. Alternative maintenance performance measures are described and discussed. The alternative measures for which source data is available are analyzed. A new performance measurement model, the Multi-Criteria Performance/Productivity Measurement Technique, and the Objectives Matrix, is described and recommended for measuring LAMPS MK III helicopter squadron maintenance performance.

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I. INTRODUCTION

A. BACKGROUND

Efficiency, effectiveness and productivity have become hot topics in recent years. The failure of the United States to maintain parity in these areas has been touted as one of the root causes of its receding competitiveness and loss of prominence in the global market place.

In 1986, President Reagan signed Executive Order No. 12552 calling for an improvement in productivity of 20 percent in all government agency operations by 1992. While this may have been considered a great step forward by some, most government agencies viewed this call-to-arms as an order to cut their costs. A focus on improvement in overall performance (productivity, efficiency, effectiveness, quality, innovation, budgetability, and quality of work life) might have been a more germane topic for the executive order. [Ref. 1: p. 10]

Currently, the entire federal government is in the middle of a strong movement to cut the budget deficit. The two areas of focus for deficit cutting measures are increased taxation and reduced spending, with the Department of Defense absorbing the largest budget reductions. Those reductions are placing

tremendous pressure on the services in their efforts to maintain their warfighting capability.

With the shrinking Navy budget, including Operations and Maintenance, Navy (O&M,N) funds, fleet commanders are being pressed into coping with expanding operational commitments on a diminishing operational budget. The LAMPS MK III[1] community, which employs the SH-60B Seahawk helicopter, is no exception. Their resources are being stretched to the limit while they are expected to support an ever expanding list of operational requirements. The primary mission of a LAMPS MK III squadron is to deploy combat ready detachments and aircrews. The very nature of the detachment oriented LAMPS mission requires commanding officers to apportion resources within a constantly changing priority structure.

The LAMPS community consists of two fleet replacement squadrons, HSL-40 and -41, and eleven operational squadrons, HSL-42 through -49, -51 and -37. The current Block I upgrade and required depot level maintenance are two of the major constraints that are facing the community by effecting the number of available aircraft. The Block II upgrade for the SH-60B helicopter is scheduled to enter service near the end of the decade. In addition, the surface platforms that employ and support SH-60B helicopters are increasing. Each East

[1] LAMPS stands for Light Airborne Multi-Purpose System. MK III refers to the third generation helicopter with the LAMPS designation.

Coast squadron is now supporting eleven surface combatants instead of ten.

The mission of a LAMPS MK III squadron is multifaceted, with primary emphasis on supporting deployable detachments at sea. This mission can be best accomplished by providing: high quality maintenance for the aircraft; maintenance technicians with sufficient training and skill development to perform the required tasks once deployed; quality training and skill development to aircrews; and ensuring that the existing squadron support structure can properly support the sea-going detachments.

A secondary facet of the mission is to provide shore-based aircrew and maintenance technicians with ample training and skill development opportunities. Two major factors affecting squadron performance are the quarterly allocation of flight hours and the mission capability of the squadron's aircraft.

Increased operational commitments, while maintenance man-hours available remain relatively constant, puts into question the adequacy of the current LAMPS MK III maintenance measurement system to cope with current maintenance demands. To ensure squadrons meet operational requirements and remain within assigned fiscal constraints, the current manner in which the LAMPS MK III community measures maintenance performance should be studied.

B. OBJECTIVES

The objectives of this thesis are to:

- Assess and evaluate the current levels of maintenance efficiency, effectiveness, and productivity within LAMPS MK III squadrons.
- Identify areas where improvement opportunities exist in the maintenance performance measurement system.
- Develop a non-financial performance measurement system that will measure the efficiency, effectiveness, and productivity of squadron maintenance efforts.

C. RESEARCH QUESTIONS

1. Primary research question:

- Is the existing maintenance measurement system the most effective for coping with the current environment facing the LAMPS MK III community? If not, where are there opportunities for improvement?

2. Secondary research question:

- What are the current measures for monitoring the effectiveness, efficiency, and capability of the maintenance process employed by the LAMPS MK III community? Do these measures reflect the quality and effectiveness of the maintenance performed? Are alternatives available?

D. SCOPE, LIMITATIONS AND ASSUMPTIONS

1. Scope

The scope of this thesis will be limited to examining the current maintenance activities of a sample of LAMPS MK III squadrons. The primary emphasis will be on evaluating non-financial measures of performance of the maintenance department and assessing the overall efficiency and

effectiveness of the department in achieving the objectives of the command. The specific areas of investigation will be:

- The existing organizational level maintenance system.
- The existing measurements of maintenance performance.
- The practicality of these measurements.

For the performance measures, only data and reports that currently exist in the Naval Aviation Maintenance Data System will be employed. The intention is to provide squadron maintenance officers with a performance measure using data available on reports that are already received by each command and not recommend any new reporting requirements.

2. Limitations/Assumptions

The data used in this thesis was gathered from the Naval Aviation Maintenance Support Office (NAMSO) and Naval Aviation Logistics Data Analysis (NALDA) databases. This material originates from the Visual Information Display System/Maintenance Action Forms (VIDS/MAFs)[2] used by each of the squadron maintenance activities. It is assumed that all of the data is accurate and that any biases are uniformly distributed throughout the population.

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[2]The Visual Information Display System/Maintenance Action Form is a multipurpose document used in the Maintenance Data Reporting system and the Visual Information Display System. OPNAVINST 4790.2E, NAMP, Vol. II, p. C-36.

Aviation Fleet Maintenance (AFM) funds will be the primary source of financial data. Because the budgeting and obligation of Aviation Depot Level Repairables (AVDLRs) funding is beyond the control of the squadron, this data will not be evaluated in determining the cost of maintenance. Flight hour funding will also not be considered because it has little direct effect on the cost of maintenance. However, aircraft flight hours flown will be considered, because of their effect on the availability of the aircraft for maintenance, and the fact that flight hours are considered a maintenance driver.

E. DATA SOURCES

1. Naval Aviation Maintenance Support Office (NAMSO) Database

NAMSO is the primary data collection facility for all aviation maintenance information. NAMSO also produces and distributes all of the monthly Maintenance Data Reports (MDRs). In addition, the NAMSO database provides this information in response to specific queries centered around individual data fields contained in the MDRs.

2. Naval Aviation Logistics Data Analysis (NALDA) Database

The NALDA database is

> ...an automated data base and information retrieval system for aviation logistics management and technical decision support. Analysis capability is provided through

> interactive query and batch processing from remote terminals. As a state-of-the-art management information system, NALDA assists users in making improved decisions affecting fleet aircraft readiness. Users can define, identify, and isolate logistics problem areas from a centralized data bank of integrated aviation logistics information. [Ref. 2: p. C-24]

NALDA provides information similar to that contained in the MDRs in response to specific queries.

3. Aviation Fleet Maintenance (AFM) Funds

AFM data was obtained from each of the fund administering activities (FAA) that support the CONUS LAMPS MK III squadrons. The FAA that supports the East Coast squadrons is Naval Station Mayport, Florida. West Coast squadron support is provided by Naval Air Station North Island, California.

4. Squadron 3-M Maintenance Summaries

Squadron 3-M Maintenance summaries are locally produced documents that highlight specific areas of interest to the squadron maintenance officer. The squadron's data analyst produces this report from information presented in the Maintenance Data Reports and the Subsystem Capability Impact Reports delivered to the squadron.

5. Interviews

Seven squadron Maintenance Officers and both wing Maintenance Officers were interviewed. The objective of the interview was to determine an operator's definition of readiness, explore implicit and explicit performance

assessment criteria, assess the current fleet awareness of performance improvement elements (effectiveness, efficiency, productivity, quality, budgetability, innovation and quality of work life), and determine the significance of AFM funds on the maintenance officer's decision making process. In addition, both the East and West Coast Wing Maintenance Officers were interviewed. These interviews attempted to determine the perspective of the reporting senior of the squadron concerning the areas of interest.

F. THESIS ORGANIZATION

1. **Chapter I:** Introduction

The environment facing the LAMPS MK III community will be discussed. In addition, the objectives, primary and secondary research questions, scope, limitations, and assumptions will be delineated.

2. **Chapter II:** Background

A brief overview of the Naval Aviation Maintenance Program, the maintenance organizational structure, and the duties of the maintenance officer will be discussed.

3. **Chapter III:** Defining Performance Measurement

The various factors affecting performance (productivity, effectiveness, efficiency, quality, innovation, budgetability, and quality of work life) will be defined and discussed. In addition, a synopsis of the performance measure model will be included. The various types of maintenance funds will be described.

4. **Chapter IV:** Research Methodology and Alternative Performance Measures

In this chapter, the sources of the data used to analyze this study will the discussed. The associated limitations involving the data selection and techniques of analysis will be analyzed. In addition, various performance measures addressing aviation maintenance will be described. The chapter will conclude with a delineation of the performance measures to be analyzed in Chapter V.

5. **Chapter V:** Data Presentation

The alternative performance measures discussed in Chapter IV will be analyzed and graphed. The significant statistical observations will be highlighted.

6. **Chapter VI:** Discussion of the MCP/PMT and Objectives Matrix

The steps for developing and using the MCP/PMT and Objectives Matrix will be delineated. Performance measures that fit the performance improvement elements will be fitted to the MCP/PMT and Objectives Matrix. The resulting performance scores derived from the model will be graphically displayed.

7. **Chapter VII:** Summary, Conclusions and Recommendations

The highlights of the thesis will be included, as well as conclusions reached from the analytical research conducted. Specific recommendations addressing performance measurement within the context of the LAMPS MK III maintenance system will be presented in this chapter. In addition, related topics for further research will be presented.

8. **Appendix A:** The Duties of the Maintenance Officer

Delineates the specific duties of a squadron maintenance officer as per OPNAVINST 4790.2E, the Naval Aviation Maintenance Program.

9. **Appendix B:** The Authorized Uses of Aviation Fleet Maintenance Funds.

The specific types of purchases for which Aviation Fleet Maintenance funds can be used as per the NAMP.

10. **Appendix C:** The Results of the Statistical Analysis.

The results of the statistical analysis on each of the performance measures are summarized. The analysis includes the Analysis of Variance (ANOVA) test, small-sample hypothesis test for two population means, and large-sample hypothesis test for two populations.

11. **Appendix D:** Activity Breakout Graphs

The graphical representations of the frequency distributions concerning the specific activity groupings will be presented.

II. BACKGROUND

A. AVIATION MAINTENANCE PRINCIPLES

A critical success factor of every naval aviation unit is its maintenance effort. A well managed maintenance activity optimizes equipment availability and minimizes downtime at a reasonable cost. A poorly organized or functioning maintenance department will misuse limited resources and over-utilize operational assets in achieving command objectives. If the maintenance activity of a command is not functioning properly, the unit will experience difficulties in functioning at its full operational potential.

Readiness is defined as "the ability of forces, units, weapons systems, or equipment to deliver the outputs for which they were assigned." [Ref. 3: p. 229] In aviation maintenance terms, readiness implies that an aircraft is able to fly safely and all systems needed to complete the assigned mission are operating. Achieving and maintaining readiness is the single most important function of an aviation maintenance department. However, measuring readiness is much more difficult than defining readiness.

Two definitions of readiness emerged from the interviews of the squadron maintenance officers. The first definition described readiness in terms of the aircraft's material

condition as reflected by the mission capability (MC), full mission capability (FMC), and partial mission capability (PMC) figures. The second definition addressed the fundamental aspect of every aviation unit, having aircraft that are flyable and safe, and capable of meeting all assigned tasking. Other items discussed concerned parts availability and properly trained personnel. It is evident that the maintenance officers have developed definitions of readiness that provide a framework for achieving the squadron's mission.

B. NAVAL AVIATION MAINTENANCE PROGRAM (NAMP)

OPNAV Instruction 4790.2E, the Naval Aviation Maintenance Program (NAMP), is the foundation on which all aircraft maintenance is based. The NAMP delineates the duties and responsibilities of all participants in the maintenance effort and provides detailed instructions for the documentation of maintenance actions. In addition, it stipulates specific reporting responsibilities and provides a basis for organizing the maintenance department in an aviation squadron.

1. Objective

The objective of the NAMP is "to achieve and continually improve aviation material readiness and safety standards established by the Chief of Naval Operations (CNO), with optimum use of manpower, material, and funds." [Ref. 4: p. 2-1] These standards include the repair of aeronautical equipment at a level that ensures the optimum

use of available resources, the protection of weapon systems through an active corrosion control effort, the active use of the Planned Maintenance Program, and the collection and use of data to improve the performance of the maintenance personnel and the material condition of the equipment.[Ref. 4: p. 2-1]

2. Performance Improvement Goals

The NAMP has listed several broad performance improvement goals in an effort to continuously improve the maintenance practiced by the fleet aviation units and meet the stated objectives. These goals are:

- Increased readiness
- Improved quality
- Improved deployability
- Improved sustainability
- Reduced costs
- Enhanced preparedness for mobilization, deployability, and contingency operations
- Enhanced supply availability
- Improved morale and retention [Ref. 4: p. 2-1]

3. Performance Elements

The NAMP notes seven performance elements that are to be the focus of the performance improvement effort. These seven performance elements are Productivity, Effectiveness, Efficiency, Quality, Innovation, Quality of Work Life, and Budgetability. These performance elements are the foundation

of the NAMP's performance improvement effort. Each element focuses on a part of the maintenance process. The NAMP charges all maintenance personnel to actively pursue any opportunity to achieve gains in any of these areas. Further discussion of the performance improvement elements will be conducted in Chapter III.

C. LEVELS OF MAINTENANCE

Aviation maintenance within the Department of the Navy is broken into three distinct strata. The delineation is based on the type of maintenance conducted and the level of assembly, subassembly, or component that can be repaired by the activity.

1. Depot-Level Maintenance

> Maintenance (that is) performed at naval aviation industrial establishments to ensure continued flying integrity of airframes and flight systems during subsequent operational service periods. D-level maintenance is performed on material requiring major overhaul or rebuilding of parts, assemblies, subassemblies, and end items. It includes manufacturing parts, making modifications, testing, inspecting, sampling, and reclamation. D-level maintenance supports lower levels of maintenance by providing engineering assistance and performing maintenance that is beyond the capability of the lower level activities. [Ref. 4: p. 3-2]

2. Intermediate-Level Maintenance

> I-level maintenance is the responsibility of, and performed by, designated maintenance activities in support of using organizations. The I-level maintenance mission is to enhance and sustain the combat readiness and mission capability of supported activities by providing quality and timely material support at the nearest location with the lowest practical resource expenditure. [Ref. 4: p. 3-1]

3. Organizational-Level Maintenance

> O-level Maintenance is normally performed by an operating unit on a day-to-day basis in support of its own operations. The O-level maintenance mission is to maintain assigned aircraft and aeronautical equipment in a full mission capable status while continually improving the local maintenance process. [Ref. 4: p. 3-1]

O-level maintenance is the primary area of focus of this thesis. In support of this objective, the data will relate to the maintenance efforts of the aircraft squadron. In addition, the squadron maintenance officer will be considered the primary individual in establishing the objectives, plans, and priorities of the maintenance department.

D. UPKEEP MAINTENANCE

There are two fundamental types of maintenance performed within the naval aviation maintenance system: rework and upkeep. The maintenance department of an aviation squadron is restricted to upkeep maintenance. Upkeep maintenance is further differentiated by being either scheduled or unscheduled.

1. Scheduled Maintenance

Scheduled maintenance is described as the "periodic prescribed inspection/servicing of equipment, done on a calendar, mileage, or hours of operation basis." [Ref. 2: p. C-30] Because this type of work is conducted on a periodic

basis, scheduled maintenance is a fairly predictable factor in the planning process.

In the LAMPS MK III community, there are two primary categories of scheduled maintenance conducted by the O-level maintenance activity: phase and calendar inspections. Both of these inspections are designed to preserve the material condition of the aircraft and inspect certain items for wear. Phase inspections are conducted on a 150 flight hour interval. Phases are major repair actions that take two to four days to complete. Calendar inspections occur at a fixed time interval. Currently, there are 7, 14, 28, 56, 112, and 224-day inspections conducted on the SH-60B helicopter. The time periods for these inspections run concurrently. When the aircraft is deployed, the time period for these inspections is halved, with the exception of the 7-day inspection.

Scheduled maintenance consists of two distinct phases. The first is the "look phase." In this phase, all the requirements for the completion of the inspection are performed, and any discrepancies or maintenance problems are documented. The second phase is the "fix phase" where the discrepancies discovered during the "look phase" are corrected.

2. Unscheduled Maintenance

Unscheduled maintenance is defined as "maintenance, other than the fix phase of scheduled maintenance, occurring

during the interval between scheduled downtime maintenance periods." [Ref. 2: p. C-36] In essence, unscheduled maintenance is the repair work required because of malfunctioning equipment. The inherent unpredictability of unscheduled maintenance often shapes the apportionment of the squadron's resources (man-hours and parts) to remedy the problem in a timely manner.

E. ORGANIZATIONAL MAINTENANCE ACTIVITY

The organizational level (O-level) maintenance activity is the lowest level in the maintenance hierarchy. It is at this level that the primary thrust of this thesis is aimed. The maintenance performed is usually at the aircraft subsystem level. Rarely do O-level technicians diagnose and repair the internal components of the equipment; instead, the component is removed and replaced.

1. Objectives

The objectives of all O-level maintenance activities are:

- Improved performance and training of personnel
- Improved aircraft, equipment, and system readiness
- Improved maintenance integrity and effectiveness for all material
- Improved safety
- Improved usage of manpower and material
- Improved planning and scheduling of maintenance

- Improved management and evaluation of work performance
- Improved quality of the end product
- Improved attainment and retention of combat readiness
- Improved continuity when aircraft or personnel are transferred between commands.[Ref. 4: p. 2-1]

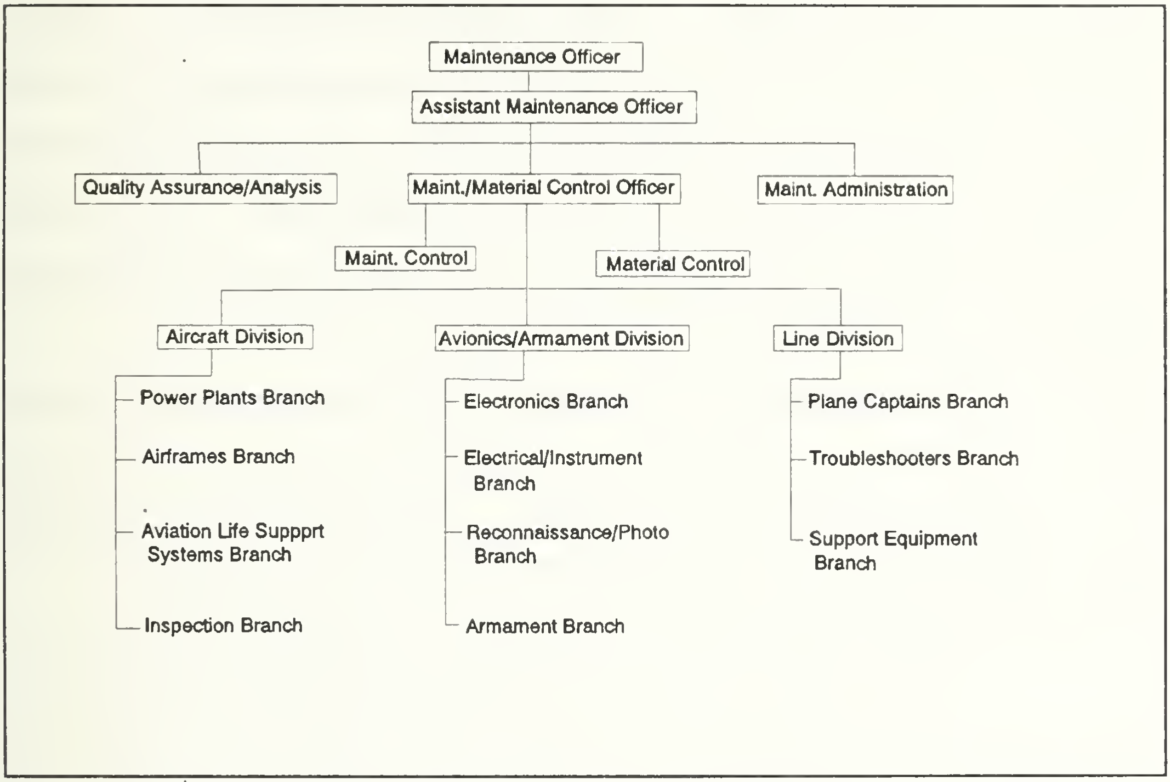

Figure 1 Typical Navy O-Level Maintenance Department Organization

2. Aviation Squadron Maintenance Organization

The NAMP, Volume II, provides the basic structure for the maintenance department organization for an aviation squadron (see Figure 1). The duties and responsibilities of the maintenance officer, subordinated line and staff positions, and various support activities are stated. This

standard organization is designed to provide a conduit for effective management.[Ref. 2: p. 3-1]

The maintenance department is headed by the maintenance officer who has overall responsibility for the functioning of the department. The department consists of three functional areas: Quality Assurance/Analysis (QA/A); Maintenance Administration; and Maintenance/Material Control (M/MC). Maintenance Administration provides administrative support for the maintenance department. Quality Assurance/Analysis provides essential post-maintenance flight safety inspections and data analysis.

Maintenance/Material Control is responsible for the Aircraft, Avionics/Armament, and Line divisions. These divisions contain the functional branches that incorporate the maintenance personnel required to repair the aircraft.

The vast majority of aviation squadrons that utilize this organizational structure are either units that deploy as a command or shore-based training squadrons. Since the deployable squadrons relocate to the ship as a whole, their organizational integrity remains intact. This allows for significant continuity among the maintenance department's activities, programs and objectives.

3. Maintenance Officer

The squadron maintenance officer heads the maintenance department and is responsible to the commanding officer for

the contribution of the department in achieving the squadron's mission and goals. In light of this, the maintenance officer pilots the formulation of the objectives, plans, and goals of the department. The maintenance officer is the final evaluator and implementor of all new procedures and processes within the maintenance department. The maintenance officer's performance evaluation is directly tied to the performance of the maintenance department; therefore, he is the primary stakeholder in any performance improvement initiative undertaken.

The responsibilities of the squadron maintenance officer are listed in Appendix A; however, they can be summed into the following four broad objectives:

- Obtain optimum utilization of assigned personnel.
- Obtain optimum utilization of assigned facilities.
- Obtain optimum material support.
- Ensure proper maintenance procedures are conducted in accordance with applicable instructions. [Ref. 5: p. 30]

These broad objectives help focus the performance improvement efforts of the maintenance department.

4. The LAMPS MK III Squadron

A typical LAMPS MK III squadron maintenance department's goals and objectives are similar to any other O-level aviation maintenance activity. Because the operational

LAMPS squadron deploys under a detachment organization, vice the entire command, there are fundamental differences in the organizational structure.

The two Fleet Replacement Squadrons, HSL-40 and HSL-41, do not utilize any detachments. This is due to the fact that they are training squadrons and do not deploy.

a. The Detachment

Detachments are small, semi-autonomous organizational units. Within the maintenance department, they are the sub-unit that actually performs the maintenance. Figure 2 depicts the typical squadron organization following the detachment concept. Because detachments deploy, all of the essential functions for stand-alone operations are included. In a sense, detachments are micro-maintenance departments.

Each detachment is staffed by technicians from the four primary specialties required to perform work on the aircraft. The specialties are aviation machinists mate (AD), aviation electrician (AE), aviation electronics technician (AT), and aviation structural mechanic (AM). A one-aircraft detachment will usually be staffed with two personnel from each discipline. A two-aircraft detachment will be augmented with either an extra AD or AE.

The detachment maintenance team is supervised by a chief petty officer (det CPO) who is responsible for the daily

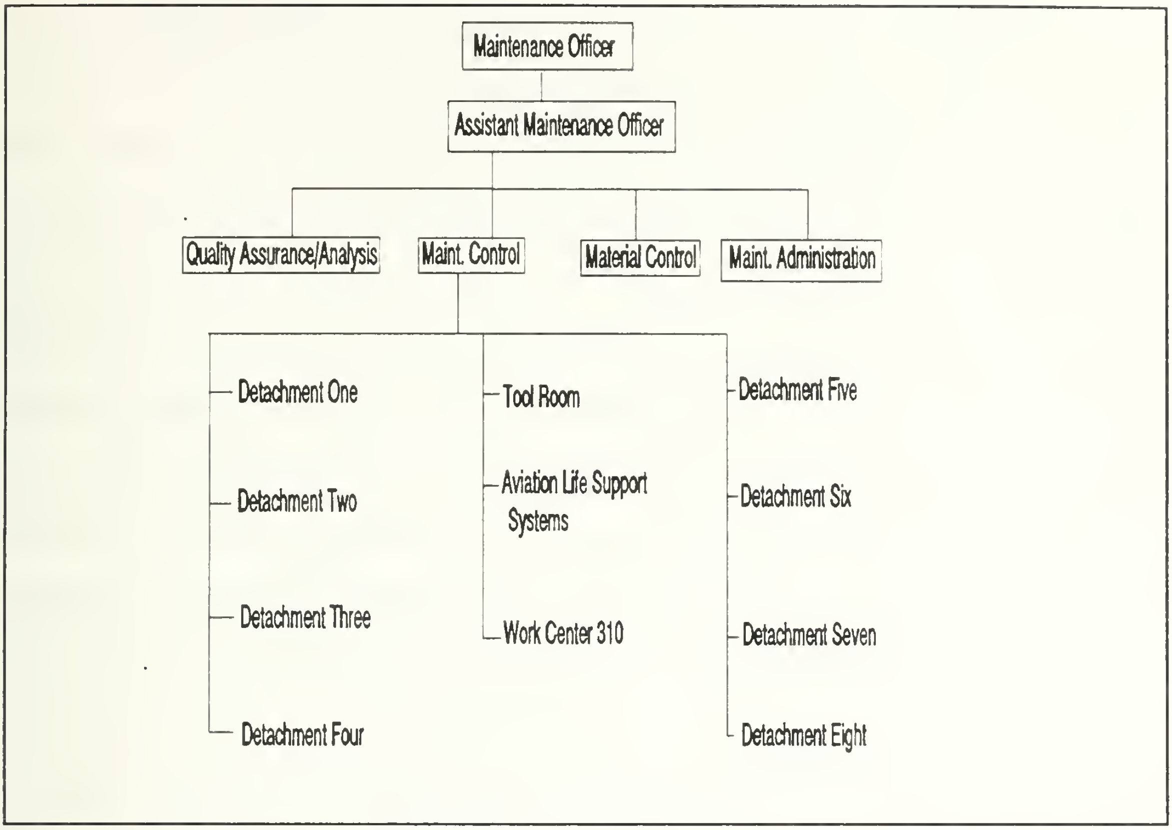

Figure 2 Typical O-Level Detachment Concept Organizational Structure

maintenance effort of the detachment. The detachment maintenance officer (det MO) has overall responsibility of the detachment's maintenance activity. When the detachment is attached to its parent squadron, the det MO is responsible to the squadron maintenance officer for the performance of the detachment. When the detachment is deployed, the det MO falls under the control of the detachment officer-in-charge (det OIC).

While the detachments are ashore, they are responsible to Maintenance Control, and the maintenance control officer, for the performance of their assigned work.

Twice daily, at the beginning of each shift, Maintenance Control establishes the priorities for each of the detachments and their respective aircraft. While the detachment is deployed, the det MO exercises the maintenance control function.

All of the Atlantic Fleet LAMPS MK III maintenance departments are organized under the autonomous maintenance unit, or detachment, concept. Aircraft and personnel are assigned to these detachments on a continuous basis. Each of the detachments of the Atlantic Fleet LAMPS MK III squadrons are assigned to a specific ship in the Atlantic Fleet on a semi-permanent basis.

All of the squadrons surveyed from the Pacific Fleet are organized under the more traditional maintenance organizational structure. West Coast squadrons form detachments approximately six months prior to the deployment. Detachments are formed for specific deployments and ships. Once the commitment is completed, the detachment may be employed to meet any other commitment with any other ship that may arise. Once all of the detachment's commitments have been met, the detachment is dissolved and the personnel are re-absorbed into the squadron's maintenance shops. In the Pacific Fleet, ships are not permanently assigned to squadrons and detachments as they are in the Atlantic Fleet. Ship/detachment assignments only last for the duration of the work-up/deployment/post-deployment cycle.

b. Support Functions

In a LAMPS MK III squadron maintenance department, the support functions of Quality Assurance/Analysis (QA/A), Maintenance Administration, and Material Control are handled in the same fashion that they are addressed in any other maintenance activity. QA/A provides the basic quality control and standardization for all maintenance practices performed within the squadron. Maintenance Administration supports the squadron and detachments by processing all routine administrative matters. Material Control provides the detachments and work-centers within the squadron with supply services. One notable exception is that quality assurance functions are assigned to the detachment technicians for their deployed periods. When the detachment returns to the parent squadron, the detachment's quality assurance requirements are filled by the squadron's QA/A department.

F. AVIATION MAINTENANCE DATA COLLECTION AND REPORTING

1. Naval Aviation Maintenance Office (NAMO)

The Naval Aviation Maintenance Office (NAMO), located at NAS Patuxent River, Maryland, is a support facility for all naval aviation maintenance activities. Its primary mission is "to coordinate aviation fleet maintenance support to ensure optimum aviation maintenance performance and fleet readiness and to provide technical support in aviation life cycle logistics and maintenance planning."[Ref. 6: p. 1]

One of the primary functions of NAMO is to provide productivity improvement support.[Ref. 6: p. 2] An activity within NAMO that assists in this endeavor is the Naval Aviation Logistics Data Analysis (NALDA) database. The NALDA database provides reports based on specific inquiries by designated users.

2. Naval Aviation Maintenance Support Office (NAMSO)

The Naval Aviation Maintenance Support Office (NAMSO) is under the command of the Naval Sea Logistics Center in Mechanicsburg, Pennsylvania. It serves as the primary collection facility for all aviation maintenance data. NAMSO also generates the various reports used by the individual maintenance activities for monitoring and self-reporting.

3. Types of Aviation Maintenance Reports

a. Maintenance Data Reports

These reports are printed monthly and are available for use by each maintenance activity. The information used to produce these reports is generated by each maintenance activity on VIDS/MAFs. One of the primary uses of the reports is to provide the basic data for the squadron 3-M maintenance summaries. In addition, these reports provide the foundation for any performance improvement effort. The most relevant reports to the squadron maintenance officer are included in Figure 3.

Monthly Production Report (MDR-2)	Lists all maintenance actions in work center (WC) sequence including technical directive (TD) compliance, and data entered in the (H-Z) Failed/Required Material block of the VIDS/MAF.[Ref. 7: p. 3-13]
Technical Directive Compliance Report (MDR-4-1)	This report gives a detailed list, by organization, of TD compliance during the reporting period.[Ref. 7: p. 3-16]
Maintenance Action by Bureau/Serial Number Report (MDR-5)	This report consolidates all maintenance actions by BU/SERNO sequence, including SE, TD compliance, and component repair at the IMA. This report is designed to provide a history of maintenance actions by BU/SERNO and is intended for O- and I-level managers, analysts and MOs.[Ref. 7: p. 3-20]
Component Repair/Beyond Capability of Maintenance Report (MDR-7)	This report provides a spread of AT (action taken) codes for maintenance actions taken by the I-level and provides the MO and the maintenance/material control officer with an overview of the entire production effort of the activity by work center and WUC within a type of equipment.[Ref. 7: p. 3-23]
Failed Parts/Parts Required Report (MDR-8)	This report is prepared from data submitted on VIDS/MAFs with TRCODE 12 or 32 and a MAL code (not 000) entered in the (H-Z) Failed/Required Material block. This report is intended for the MO, material control officer, and work center supervisors.[Ref. 7: p. 3-26]
Repair Cycle Data Report (MDR-9)	This monthly report is a detailed list, by organization, showing the number of days of turnaround time (TAT) and the elements that compose the TAT for each repairable component processed through the I-level as documented on the VIDS/MAF, or Metrology Equipment Recall (METER) card TRCODE 31 or 32.[Ref. 7: p. 3-28]
Corrosion Control/Treatment Report (MDR-11)	This report is designed for monitoring the Corrosion Prevention and Control Program or for investigating the amount of corrective corrosion treatment necessary.[Ref. 7: p. 3-32]
No Defect Report (MDR-12)	This report shows the amount of time and effort expended on maintenance for which there is no malfunction or alleged malfunction.[Ref. 7: p. 3-34]

Figure 3 Maintenance Data Reports

b. Subsystem Capability and Impact Reporting (SCIR)

SCIR reports show an equipment's mission capability. These reports are prepared from VIDS/MAF documents which

have a valid equipment operational capability (EOC)[3] code in the Repair Cycle or Maintenance/Supply Record section. [Ref. 7: p. 3-38]

See Figure 4 for a summary of the SCIR reports that are used by the O-level maintenance officer.

c. *Squadron Monthly Maintenance Summaries*

As mentioned in Chapter I, the 3-M Maintenance Summary is a report that is generated by the squadron's data

Monthly Equipment Discrepancy and Utilization Report (SCIR-3)	This report is designed to show, by BU/SERNO, the total number of discrepancy hours limiting the equipment from performing its assigned mission or function during the reporting period. This report also denotes equipment utilization.[Ref. 7: p. 3-38]
Monthly Equipment Capability Report (SCIR-4)	This report is designed to reflect equipment capability to perform its assigned mission/function during a reporting period.[Ref. 7: p. 3-40]
Monthly Equipment Mission Capability Summary Report (SCIR-5-1)	This report is designed to display SCIR hours by mission category and awaiting maintenance (AWM) hours by reason codes, summarized for a given EOC code and associated WUC during a reporting period.[Ref. 7: p. 3-42]
Monthly Equipment Mission Capability Bureau/Serial Summary Report (SCIR-5-2)	This report shows SCIR hours by mission category and AWM hours by reason codes, summarized by a given EOC code and associated WUC by BU/SERNO.[Ref. 7: p. 3-44]

Figure 4 Subsystem Capability Impact Reports

analyst. It is a synopsis of those maintenance statistics that are considered important by the command. The data for the report is generated from the Maintenance Data Reports

[3] The Equipment Operational Code (EOC) is a three-character alphanumeric code that identifies the degree of degradation to mission capability and the system responsibility for the degradation. [Ref. 2: p. C-8]

(MDRs) and the Subsystem Capability Impact Reports (SCIRs) provided to the squadron on a monthly basis.

The LAMPS MK III squadrons on the East Coast complete the 3-M summary according to direction promulgated by their reporting senior, HSLWLANT. A comparable requirement does not exist for the West Coast squadrons. This may be the result of not having a type-wing until recently. However, the maintenance summaries generated by the West Coast squadrons highlight items that the command structure, primarily the squadron maintenance officer and material control officer, deem important.

G. TYPES OF AVIATION FUNDING

Currently there are three categories of aviation funding in use by the U.S. Navy in budgeting and accounting for aviation activities: Flight Operations funds; Aviation Fleet Maintenance funds; and Aviation Depot Level Repairables funds.

1. Flight Operations Funds (OFC-01)(OPTAR)

Flight Operations funds are used to primarily pay for the fuel used by the squadron in flying its assigned hours. There are various consumables, like office supplies and flight clothing that are included in this funding title, however the costs of these are minimal compared to the cost of the fuel. These costs are irrelevant in determining a budgetability measure for the squadron maintenance department.

2. Aviation Fleet Maintenance Funds (OFC-50)(OPTAR)

Aviation Fleet Maintenance funds are the primary source of funds for the aviation squadron maintenance officer to purchase repairable parts and consumable items that pertain to the maintenance of the aircraft. In addition, several indirect categories are included in this fund pool. This is the pool of funds that the maintenance department has direct control over and reflects the day-to-day maintenance cost of the aircraft. AFM will be the source of data for all budgetability measures developed in this thesis.

3. Aviation Depot-Level Repairables (AVDLRs) Funds

Aviation Depot-Level Repairables (AVDLRs) funds are used to finance the depot-level repair or replacement of parts that are beyond the maintenance capability of the squadron or intermediate maintenance level. The IMA has primary control over whether an AVDLR charge is incurred and thus retains control over these funds. [Ref. 2: pp. 6-130,132] This eliminates this type of funding from the scope of this thesis.

The squadron maintenance officer is concerned with those parts that fall within the auspices of this system, but has no control over how these funds are employed. As long as a carcass is turned in for a repairable part, the squadron is only charged a fraction of the total cost of the item. If the squadron fails to return the carcass of an AVDLR item, then the squadron is charged full price. In either case, the

source of the funds for these parts comes from the squadron's AFM account. Still, it is imperative that the squadron maintenance officer monitor any transaction involving AVDLR parts due to the possible negative effect an unreturned part could have on the AFM funds available. However, these funds provide little information in developing a budgetability measure for an aviation squadron.

H. AVIATION FUND BUDGETING

The method employed in the budgeting process to estimate these funds varies depending upon the type of funds in question. Flight Operations funds are determined primarily on the cost of aviation fuel required to operate an aircraft for an hour. This hour of flight is an average hour, designed to reflect some ground time as well as flight time. The price of fuel is determined each year by the contract that is awarded.

Aviation Fleet Maintenance (AFM) funds and Aviation Depot Level Repairables funds are estimated based on historical averages. The total costs incurred over a previous time period is divided by the total hours flown during the same period. [Ref. 8: p. 42] AFM and AVDLRs are essentially average costs. This average cost is then augmented for an increase in prices and then multiplied by the estimated flight hours for the next period to determine the budget request for that period.

Aside from the major accounting differences between the Atlantic and Pacific LAMPS squadrons with regards to AFM, there existed a fundamental difference between these camps with regard to AFM usage. On the East Coast, an AFM budget is submitted by each squadron to HSLWLANT. The wing in turn, submits the combined AFM budget to the FAA, NS Mayport. NS Mayport then includes the AFM request with the base budget and forwards that on to Commander, Naval Air Force Atlantic Fleet. When the grant is awarded, the process is reversed, with each squadron being accountable to the wing for their usage of the AFM funds.

At NAS North Island, the LAMPS squadrons do not submit a budget to HSLWPAC for AFM funding. NAS North Island submits its AFM budget request for all of the aviation activities on the base. When the grant is made, it is given to the NAS North Island comptroller. There is no attempt to further apportion the money to the type wings or individual squadrons. Squadron maintenance officers are instructed to obligate funds and order parts until instructed by the comptroller to cease. This procedure is adequate provided one squadron or community doesn't require an excessive amount of AFM funds to repair an emergent, high-priority problem. This procedure fosters an attitude of ambivalence toward AFM usage within the squadron maintenance department, which is in conflict with the responsibility of the maintenance officer to "employ sound

management practices in the handling of personnel, facilities, and material." [Ref. 4: p. 3-5]

I. DEFICIENCIES IN BUDGETING FOR AFM

There are several notable deficiencies associated with using an average cost approach for estimating AFM costs. The first is that an average is nothing more that a picture of the previous period. The use of an average cost figure assumes that all of the costs associated with maintaining an aircraft are directly variable based on flight hours. There is little predictive value in this point estimate.

Secondly, the average cost fails to account for costs that are incurred regardless whether the aircraft flies. There are certain costs, for example tools, that occur on a basis other than flight hours. Tools are purchased using AFM and yet are included in the average cost of operating the aircraft.

Third, by using an average cost, the budgeted AFM will only be accurate if the actual flight hours flown exactly matches the budgeted hours. If the squadron's flight hours exceed the hours used in the budget, the amount of AFM granted to repair the aircraft will be insufficient to properly maintain the aircraft unless additional funds are made available.

J. SUMMARY

In this chapter, the following topics were discussed: the principles of aviation maintenance; the Naval Aviation Maintenance Program (NAMP) and its objectives toward aviation maintenance; the levels of maintenance within the U.S. Navy; the various types of maintenance conducted; the types of O-level organizational structures; the duties of the squadron maintenance officer; and the various reporting systems and reports available to the maintenance officer.

A discussion of the types of aviation funds closed out this chapter. In addition, the procedure by which the AFM budget was developed and the flow of requests and funds was highlighted. Finally, the peculiarities in the budgeting and accounting of AFM between the Atlantic and Pacific Fleets were discussed.

This chapter provided a background of all of the factors affecting aviation maintenance in today's environment. The next chapter will discuss the basic tenets of performance measurement and list the current measures used to gauge maintenance performance in a LAMPS MK III helicopter squadron.

III. DEFINING PERFORMANCE MEASUREMENT

In any organization, performance must be measured. If managers don't measure, they will be unable to determine whether their unit is fulfilling organizational objectives. It is obvious that any time objectives are established, performance must be measured to determine if the objectives are achieved, and to what degree. Put simply, measuring performance is one of the cornerstones of management control.

Within the context of aviation maintenance, performance is measured in a variety of manners. The metrics range from the ubiquitous Mission Capability and Full Mission Capability Rates to documentation and message error rates. In each case, the intent is to provide the manager with some level of feedback to evaluate and monitor the performance of the department.

A. FACTORS IN DEVELOPING A PERFORMANCE MEASUREMENT

Any measure of performance is more often than not a surrogate measure. Because of the nature of the system or the limited resources available, the actual performance of a system or unit is rarely measured. Instead, surrogate measure are used to infer the performance of a system. Currently, the

measure of mission capability (MC/FMC/PMC/NMC) is a surrogate measure of aviation maintenance.

Performance measures can be broken in to two categories: input and output. An input measure, is a metric of the resources used by a system in the completion of its assigned activity. An example of an input measure is the amount of direct material used compared to the amount of direct materials expected to be used.

An output measure is a measure of the results of the system. The output measure differs from the actual performance of the system in that the output measure examines only one or two factors of the system. The relation derived from these one or two factors is used to make an inference as to the performance of the entire system. An example of an output measure is the average number of maintenance man-hours per flight hour (MMH/FH).

In the measurement of performance, several objectives must be considered. These objectives assist in developing a performance measure that is effective and valuable. A performance measure that doesn't attempt to optimize these objectives will fail to be of any value to the manager. Figure 5 highlights some criteria that should be considered in evaluating performance measures.

Validity	Does the measure or set of measures in fact measure or specify that which it purports to do?
Accuracy and Precision	Does the measurement system accurately and precisely measure the "true" statistic of a given phenomenon?
Completeness	In the case of a measurement system where we are interested in completely specifying the behavior of a phenomenon, the total set of measures in the system should be collectively exhaustive or include all measurable variables.
Uniqueness	Specific measures should be unique and thus should not be redundant or overlap other measures.
Reliability	Measures should consistently provide valid results.
Comprehensibility	Measures used should be simple and understandable as possible and still convey the message and meaning intended.
Quantifiability	A measure should be quantifiable in order to better understand its meaning.
Controllability	Measures should reflect variables, factors, relationships or any phenomenon that the organization has control over.
Cost Effectiveness	The measures should be cost effective.[Ref. 9: pp. 68-69]

Figure 5 Criteria for Evaluating Performance Measures

B. SEVEN ELEMENTS OF PERFORMANCE MEASUREMENT

There are seven independent, though not mutually exclusive, elements for measuring performance. Every manager in an organization either monitors, evaluates, or controls at least one of these measures of organizational performance. These seven elements are:

- Effectiveness
- Efficiency
- Quality
- Productivity
- Quality of Work Life
- Budgetability (Profitability)[4]
- Innovation (product and process) [Ref. 9: p. 248]

These performance measurement elements are identical to the seven performance improvement elements delineated by the Naval Aviation Maintenance Program (NAMP).

These seven elements are the fundamental factors of performance. Each performance improvement element describes a unique aspect of the performance of an organization or activity. Figure 6 graphically displays the location of each of the seven performance improvement elements in a typical system. As depicted, these seven elements are pervasive in the operation of the system and attempt to develop a "whole-system" view of the organization's performance. These performance elements provide the framework for evaluating the performance of the LAMPS MK III squadron's maintenance department and for establishing a performance measurement model.

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[4] Profitability is primarily a term employed in the private sector, budgetability is more appropriate for public sector activities and therefore more relevant to this study. In addition, the NAMP uses budgetability to describe this element.

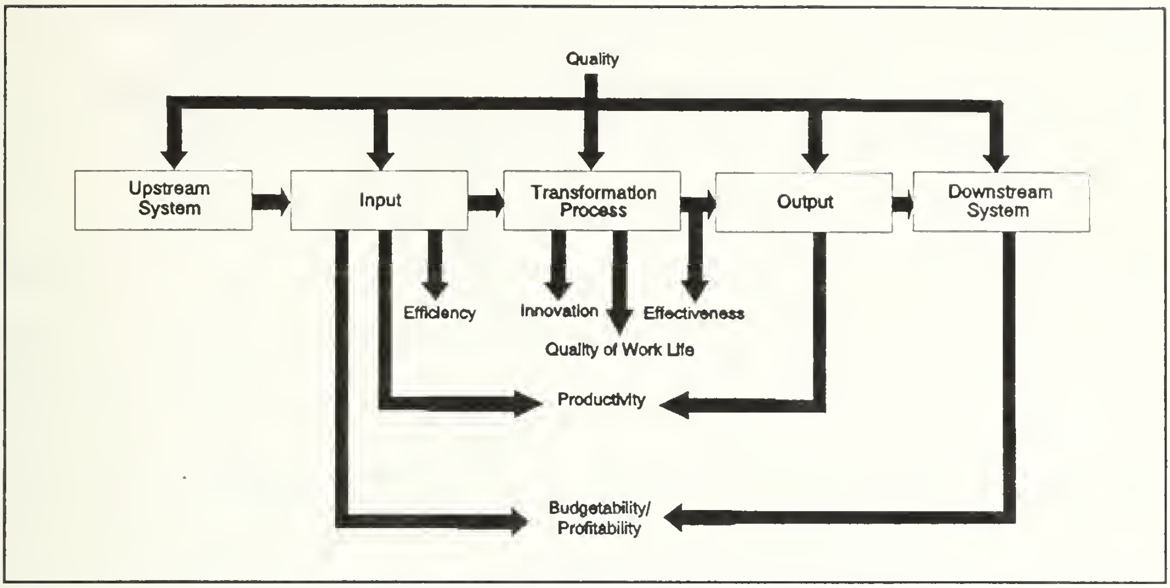

Figure 6 Organizational System and the Operational Definitions of Seven Performance Criteria

1. Effectiveness

Effectiveness is defined as "the degree to which things are produced that are of correct quality (zero discrepant) and within the allowed process or flow times."[Ref. 10: p. 41] The Naval Aviation Maintenance Program defines effectiveness as a function of the outputs of a system and their relationship to the achievement of the unit's goals.[Ref. 4: p. 2-1]

In measuring effectiveness, a comparison is made between what was planned and what was accomplished. Figure 7 provides an operational definition of effectiveness. Since, effectiveness metrics follow the transformation process and measure the results of the system, they are output measures. [Ref 9: p. 42]

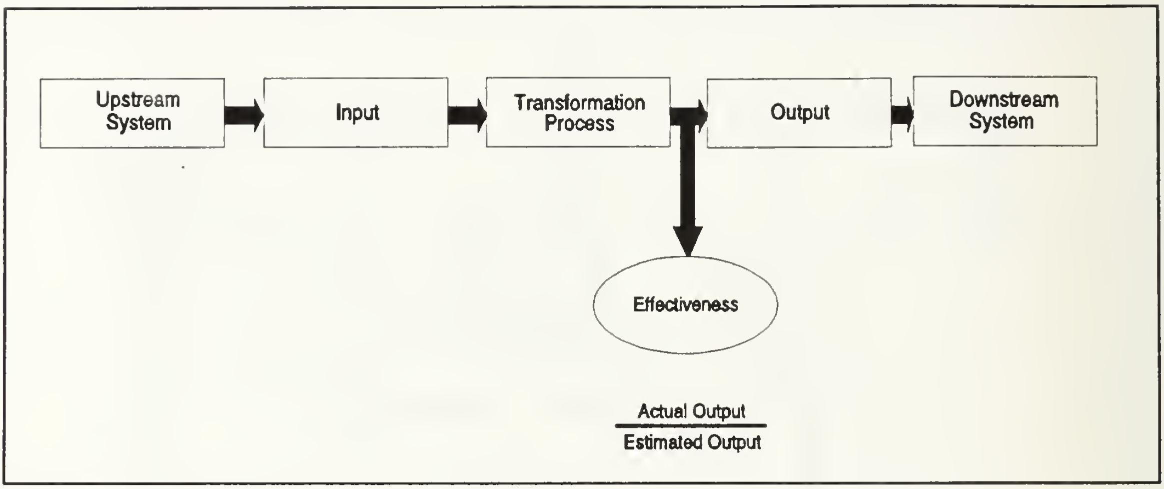

Figure 7 Operational Definition of Effectiveness

2. Efficiency

Efficiency is defined as "the degree to which the system uses the right resources; e.g., no unplanned overtime,

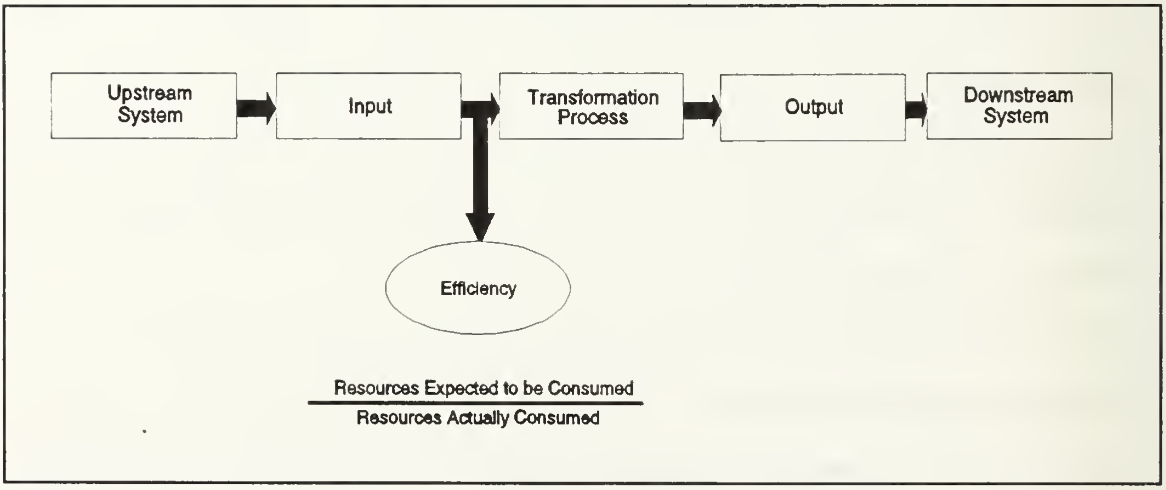

Figure 8 Operational Definition of Efficiency

additional personnel, or additional equipment." [Ref. 10: p. 41] The NAMP describes efficiency as "the relationship

between actual and planned resources. It tells how well the resources were used, as in manpower utilization." [Ref. 4: p. 2-2]

Efficiency is a comparison between the quantity of resources that were expected to be used and those actually used. Figure 8 depicts the position of efficiency measures within the system. These resources can be any input to the process, money, labor hours, etc. The planned usage is determined by employing standards, estimates or budgets. Therefore, efficiency measures inputs to a system. [Ref. 9: pp. 42-43]

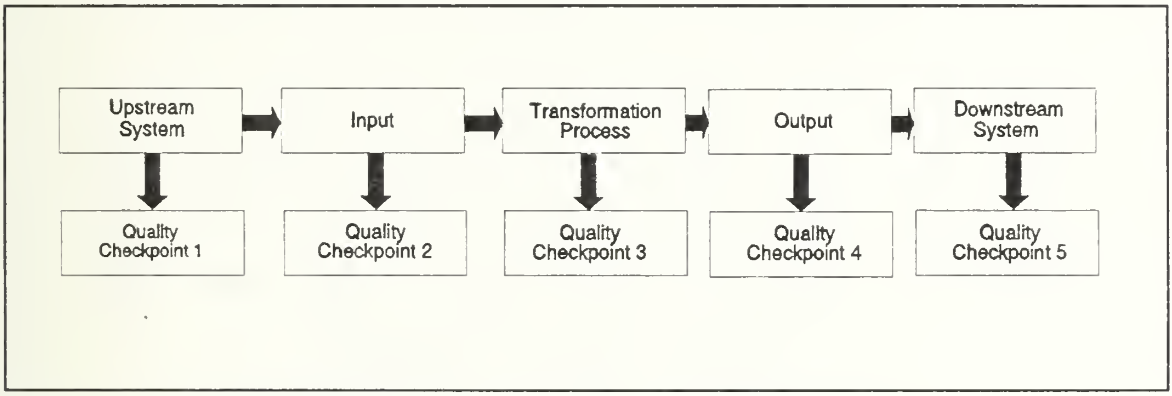

Figure 9 Operational Definition of Quality

3. Quality

Quality is "the degree to which the system conforms to requirements, specifications, or expectations." [Ref. 9: p. 43] The NAMP defines quality as "the degree of satisfaction in a product or service as determined by the customer." [Ref. 4: p. 2-2] Figure 9 depicts the prevalence of quality on an organization. In this case, quality describes how well

something is done. In a TQL responsive organization, the standards that determine quality are driven by the needs and requirements of the customer.

4. Productivity

Productivity is defined as:

> The relationship of the amount produced by a given system during a given period of time, and the quantity of resources consumed to create or produce those outputs over the same period of time. [Ref. 9: p. 3]

Productivity is further defined in the NAMP as:

> The outputs created by the system to the inputs required to create those outputs, as well as the transformation process of inputs to outputs. [Ref. 4: p. 2-1]

In essence, productivity refers to how many tasks are

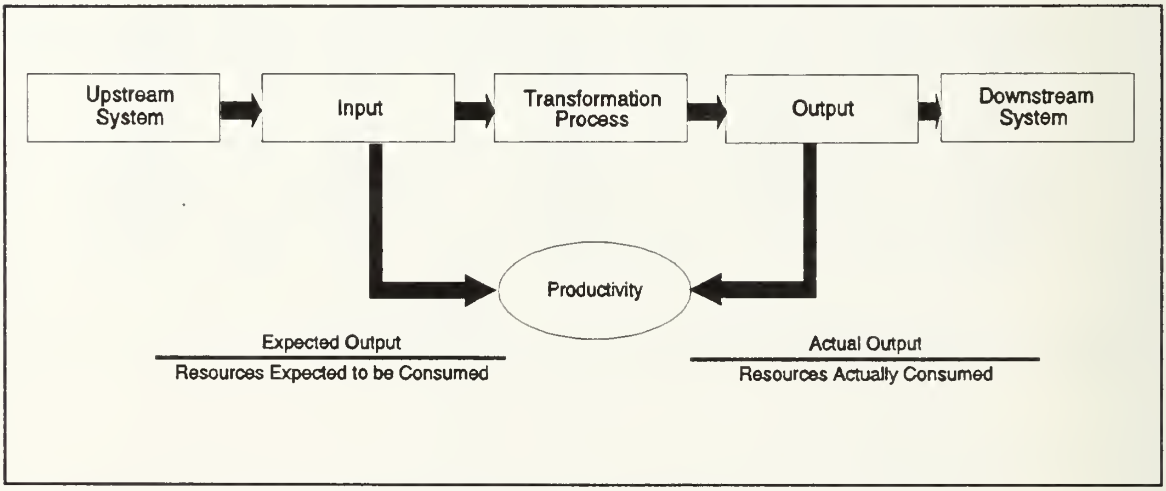

Figure 10 Operational Definition of Productivity

completed over a given time period. Figure 10 depicts productivity within the context of the organizational system. It is important to remember that completing the job correctly is a primary factor of productivity.

5. Quality of Work Life

Quality of work life is "the way participants in a system respond to sociotechnical aspects of that system." [Ref. 9: p. 44] Figure 11 locates quality of work life in the organizational system. Within the Naval Aviation Maintenance Program, quality of work life is defined as "a function of morale and other factors which affect personnel pride and motivation." [Ref. 4: p. 2-2]

In essence, quality of work life considers how the people within the system feel toward the system. In the military, this factor is often called "morale." Quality of work life affects the transformation process in the system. If quality of work life is high, and the workers enjoy what

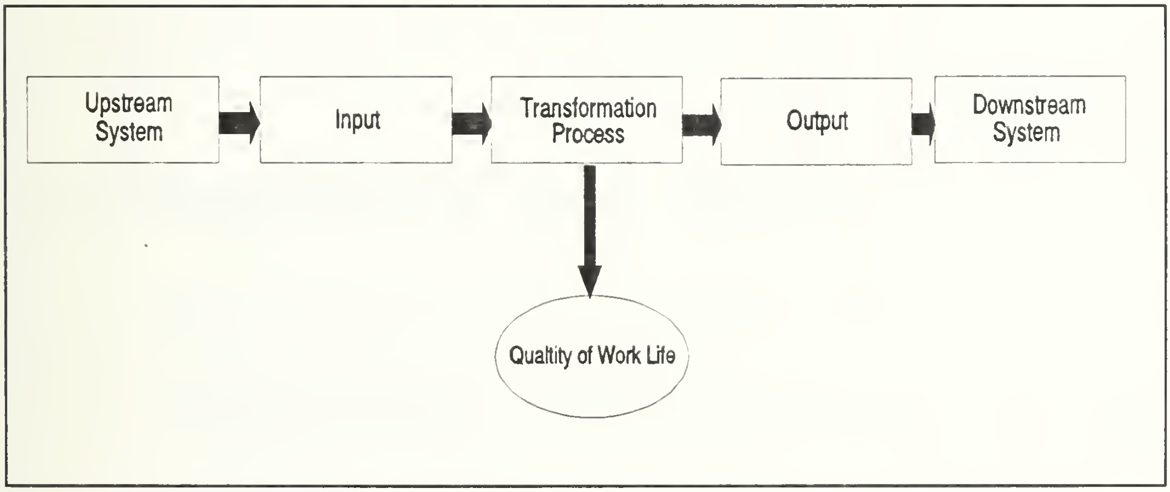

Figure 11 Operational Definition of Quality of Work Life

they are doing, the performance of those workers in the transformation process is higher. Quality of work life

measures are entirely subjective and are usually evaluated through questionnaires and surveys.

6. Budgetability (Profitability)

While profitability is defined as "the relationship between total revenues (or in some cases, budget) and total costs (or in some cases, actual expenses)." [Ref 9: p. 43] The concept of budgetability is more applicable to the structured military accounting system. In the NAMP "budgetability is the ability to perform the assigned mission within allotted resources." [Ref. 4: p. 2-2] Figure 12 depicts the relationship of budgetability (profitability) to the organizational system diagram.

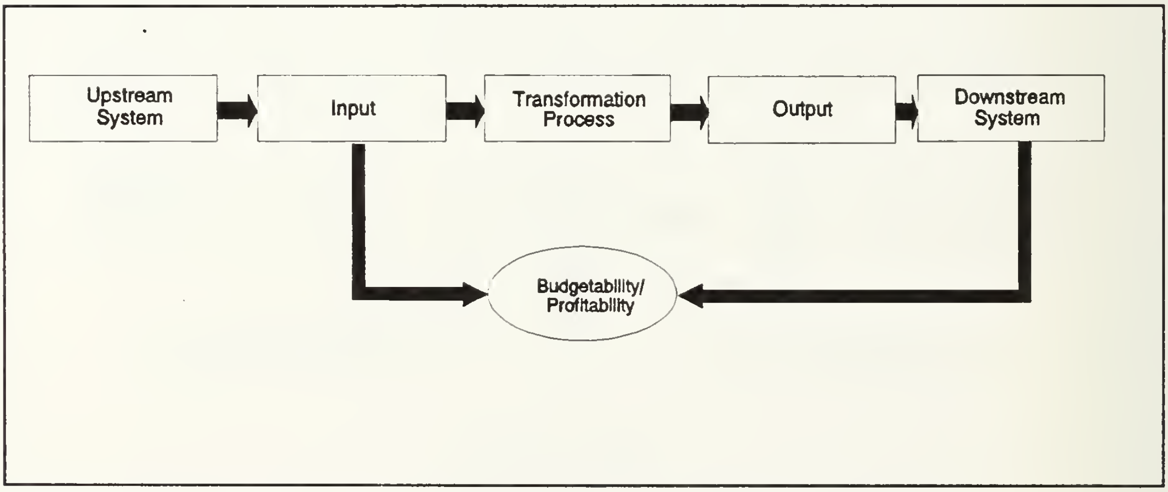

Figure 12 Operational Definition of Budgetability/ Profitability

All naval units are given budgets, either as Total Obligational Authority (TOA) or as Operating Targets (OPTARs). LAMPS MK III squadrons are considered "cost centers" and are given an OPTAR each quarter. This OPTAR is divided into

several categories including funding for flight hours, reparable parts and flight clothing, and training and travel.

7. Innovation

Innovation is "applied creativity." It refers to the process of either improving the existing system or inventing new processes and products. [Ref. 9: p. 45] See Figure 13. Innovation within the NAMP is defined as "creativity applied to the transformation process." [Ref. 4: p. 2-2]

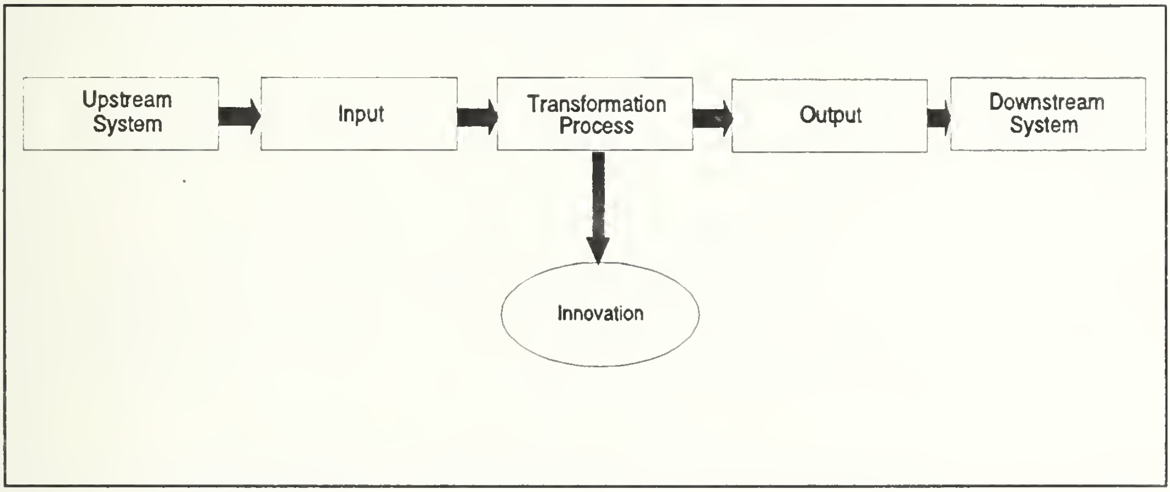

Figure 13 Operational Definition of Innovation

Within the Total Quality Leadership framework, this is one of the most important factors and yet it is the hardest to actually measure. Innovation is crucial because it is the source of improvements that are to be made to the system.

C. CURRENT PERFORMANCE MEASUREMENT IN AVIATION MAINTENANCE

Readiness is defined as "the ability of forces, units, weapons systems, or equipment to deliver the outputs for which

they were designed." [Ref. 3: p. 299] Readiness is a term common throughout the military describing a unit's or equipment's ability to perform in a combat situation. This is a somewhat arbitrary measure of performance because first, it is an estimate and second, when a combat situation arises, there are no guarantees that a piece of equipment will be used effectively. This is primarily due to the integral involvement of people in the system.

As described previously in Chapter II, the squadron Maintenance Officers that were interviewed defined readiness as the ability to meet commitments and have flyable aircraft available. In this case, meeting a commitment by having an aircraft in the air or embarked on a ship when it deploys provides little assurance as the how effective that asset will be employed. The key factor is the personnel employing the aircraft. This points to a conclusion that any measure of readiness is nothing more than an arbitrary statistic.

The primary indicator of readiness is the Material Condition Reporting status of the aircraft. These operational capability designations are a series of categories that describe an aircraft's overall ability to perform some or all of the missions for which it is assigned. Figure 14 describes the various different designations within the Material Condition Reporting System. These measures are mutually exclusive and provide a snapshot of the performance capability of the aircraft at a particular point in time. The Material

Optimum Performance Capability (OPC)	The maximum capability for successful completion of all assigned missions, through the availability of all equipments, within the mission capability of an aircraft[Ref. 7: p. C-17].
Mission Capable (MC)	The material condition of an aircraft indicating it can perform at least one and potentially all of its designated missions, categories A through L, as defined in the applicable Mission Essential Subsystem Matrix (MESM). MC is further defined as the sum of Full Mission Capable (FMC) and Partial Mission Capable (PMC)[Ref. 7: p. C-17].
Full Mission Capable (FMC)	The material condition of an aircraft or training device, indicating that it can perform all of its missions as assigned in the applicable MESM[Ref. 2: p. C-22].
Partial Mission Capable (PMC)	The material condition of and aircraft or training device, indicating that it can perform at least one, but not all of its missions...as defined in the applicable MESM[Ref. 2: p. C-22].
Partially Mission Capable-Supply (PMCS)	The material condition of an aircraft or training device, indicating that it can perform at least one, but not all of its missions because maintenance required to clear the discrepancy cannot continue due to a supply shortage[Ref. 2: p. C-22].
Partially Mission Capable-Maintenance (PMCM)	The material condition of an aircraft or training device, indicating that it can perform at least one, but not all of its missions because of O- or I-level maintenance requirements existing on the inoperable subsystem(s)[Ref. 2: p. C-22].
Not Mission Capable (NMC)	Not Mission Capable refers to "the material condition of an aircraft or training device, indicating that it is not capable of performing and of its missions[Ref. 2: p. C-22].
Not Mission Capable Supply (NMCS)	The material condition of an aircraft or training device, indicating that it not capable of performing any of its missions because maintenance required to clear the discrepancy cannot continue due to a supply shortage[Ref. 2: p. C-22].
Not Mission Capable-Maintenance (NMCM)	The material condition of an aircraft or training device, indicating that it is not capable of performing any of its missions because of O- or I-level maintenance requirements[Ref. 2: p. C-22].

Figure 14. Summary of Material Condition Reporting Status Designations

Condition Reporting System encompasses the primary means currently utilized for measuring the "readiness" of an aircraft and thus the associated maintenance effort.

D. THE MULTI-CRITERIA PERFORMANCE/PRODUCTIVITY MEASUREMENT TECHNIQUE (MCP/PMT) AND THE OBJECTIVES MATRIX

The Multi-Criteria Performance/Productivity Measurement Technique (MCP/PMT) is an "innovative, widely applicable, and reasonable simple approach to measuring group performance."[Ref. 1: p. 214] The MCP/PMT, when used in conjunction with the Objectives Matrix, provides a system of measuring the performance of an organization in each of the seven performance elements: effectiveness, efficiency, quality, productivity, quality of work life, budgetability, and innovation. Within each performance element, the observed performance is normalized through the use of a common scale that ranks performance figures. These scores are then weighted by their relative importance to the organization and aggregated for a total performance score. The comparison of the individual performance element's score and total performance score over time will assist the management of the organization to observe the results of any efforts at performance improvement.[Ref. 1: p. 285] Figure 15 shows an example of the Objectives Matrix used in conjunction with the MCP/PMT model.

Performance Elements

	Effectiveness	Efficiency	Quality	Productivity	Budgetability	QOWL	Innovation	Score
Performance Measure								
Actual Performance								
Performance Matrix								100
								90
								80
								70
								60
								50
								40
								30
								20
								10
								0
Performance Score								
Subjective Weighting								
Weighted Score								

Total Performance Score = ______

Figure 15 The Objectives Matrix

The basic goal of any performance measurement process is to "develop relationships between measures of output and measures of input that enable practitioners to make decisions and better manage their systems."[Ref. 9: p. 28] In addition to meeting this goal, the MCP/PMT enables comparison of the performance element against a family of measures. The MCP/PMT can be employed to provide feedback to the units management. [Ref. 1: p. 276] Within the framework of aviation maintenance, the performance measurement model (MCP/PMT) can be used to identify areas that require further attention by the maintenance department leadership. In addition, the MCP/PMT will provide the squadron maintenance officer a tool to measure the performance of the department in the areas of efficiency, effectiveness, productivity, quality, budgetability, quality of work life and innovation. The performance improvement model will help quantify the effects of any performance improvement initiatives undertaken by the maintenance department.

E. MODEL SELECTION

The MCP/PMT model and the Objective Matrix combination was chosen from a variety of performance improvement models researched for three reasons. First, the MCP/PMT model and Objectives Matrix are simple to use. The model divides the performance of a system into the seven performance elements and yields a single performance score. In addition, the model

closely resembles a variety of matrix-type measurement systems currently in use by the aviation community.

The second reason for choosing the MCP/PMT-Objective Matrix team is because it focuses on the seven performance improvement elements that are highlighted in the NAMP. This model fits easily into the structure of the existing regulations and assists the squadron in meeting the associated performance improvement requirements.

Third, this model assists the user in evaluating the goals and objectives of the system being examined. This model helps by identifying the activities within a maintenance department that directly support each of the seven performance improvement elements.

F. SUMMARY

The seven elements of performance measurement were covered in this chapter. In addition, several considerations in measuring performance were outlined. The current performance measures existing in aviation maintenance were highlighted. And finally, fundamental concepts behind the Multi-Criteria Performance/Productivity Measurement Technique (MCP/PMT) and the Objectives Matrix were introduced.

Chapter IV will provide a discussion of the research objectives of this thesis. The statistical techniques and tests that will be used in the analysis of this study will be explained. In addition, the chapter will include a variety of

possible performance measures within the context of five of the seven performance improvement elements.

IV. RESEARCH METHODOLOGY AND ALTERNATIVE PERFORMANCE MEASURES

This chapter will begin with a description of the four sources for the data used in this study. The various statistical tests will be delineated, in conjunction with the threshold of statistical significance. This chapter will conclude with a description of several alternative measures of aviation maintenance performance within the guidelines of five of the seven performance improvement elements.

A. DATA SOURCES

As mentioned in Chapter I of this thesis, data was gathered from a variety of sources.

1. 3-M Aviation Individual History Summary

The primary report used for the data analyzed in this study was the 3-M Aviation Individual Aircraft History Summary, NAMSO 4790.A7166-01. This report provided a variety of maintenance statistics about each aircraft bureau/serial number active during the time period of January 1991 to December 1992, and broke the information into monthly periods. The items of interest are included in Figure 16.

A problem arose with the information provided in this report; some of the data fields about particular aircraft were

```
Organizational (ORG) Code
Element In Service (EIS) Hours
Total MC Percentage
Total FMC Percentage
Not Safely Flyable (NSF) Hours-Maintenance
Not Safely Flyable (NSF) Hours-Supply
NMC-Unscheduled Maintenance Hours
NMC-Scheduled Maintenance Hours
NMC-Supply Hours
PMC-Maintenance Hours
PMC-Supply Hours
SCIR-Maintenance Hours
SCIR-Supply Hours
Total Flight Hours
Total Flights
Total Ship Flight Hours
Total Ship Flights
Scheduled Direct Maintenance Man-Hours
Unscheduled Direct Maintenance Man-Hours
Cannibalization Items
Cannibalization Man-Hours
Corrosion Man-Hours
Number of Aborts
```

Figure 16 3-M Aviation Individual Aircraft History Summary Data Fields

incomplete. The report was received unscrubbed, meaning all the available information was displayed, regardless of whether all required data fields were complete. In the data fields for material condition status (FMC/PMC/NMC), Element In Service (EIS) time, flight hours, and flights flown, incomplete information was supplemented with data gathered from the Flight Activity and Inventory (0712) Report. According to personnel at NAMSO, approximately 82 percent of the NAMSO database is complete. The primary reason given by NAMSO for this condition is that the documentation completed by the individual squadrons is never received at their

facility. This lack of data forced the elimination of one squadron from analysis in this thesis.

2. Flight Activity and Inventory (0712) Report

The second source of information was the Flight Activity and Inventory Report (0712) produced from the Naval Aviation Logistics Data Analysis (NALDA) database. This report provided the following data for the period June 1990 to May 1993: aircraft in reporting inventory, flight hours, sorties, EIS hours, NMCM-Scheduled hours, NMCM-Unscheduled hours, NMCS hours, and PMCM hours. The information in this report also provided backup for the incomplete fields in the NAMSO 3-M Aviation Individual History Summary.

3. Equipment Condition Analysis (0500) Report

The third report used as a source of performance data was the Equipment Condition Analysis (0500) Report. This NALDA produced report was the source of the number of maintenance actions completed by organizational code (ORG)[5] during the months selected, June 1990 to May 1993. This information was matched to the aircraft by the reporting organizational code.

Maintenance actions were often divided as aircraft were transferred between organizational codes within the same

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[5] An Organizational Code is a structured three character alphanumeric code that identifies activities within a major command. [Ref. 2: p. C-8] In the LAMPS MK III community, organizational codes are used to identify detachments and the shore-based work force within each squadron.

month. This posed little difficulty as long as aircraft were transferred to another detachment within the same squadron. However, when aircraft were transferred between squadrons, the maintenance actions were assigned to the organizational code under which the maintenance information from the 3-M Aviation Individual Aircraft History Summary was reported.

4. Comptroller Reports

There were two types of data used in the analysis of data for budgetability measures: flight hours flown and AFM data. The data concerning Aviation Fleet Maintenance funds was gathered from the comptroller of NAS North Island, California for all of the Pacific Fleet LAMPS units and NS Mayport, Florida for the Atlantic Fleet commands. These reports identified what amount of AFM was executed by month from January 1991 to December 1992.

NAS North Island is the Fund Administering Activity (FAA) for all units stationed there. The comptroller department receives the total amount of AFM that is granted each year for all activities at the base. NAS North Island continues to monitor the execution of AFM transactions regardless which numbered fleet the activity is operating under. Every dollar of AFM that is executed by deployed LAMPS detachments is counted towards the parent squadron's total AFM expenditure for the year.

Due to the type of accounting system and AFM execution procedures in place, AFM expenditures for each operational squadron by month were unavailable. Instead, a monthly total for all operational squadrons was generated.

For the East Coast, Naval Station Mayport is the FAA for the Atlantic Fleet LAMPS squadrons. However, only AFM transactions that occur within the Atlantic and Second Fleets are tracked by this FAA. Any transactions that are executed by detachments supporting Sixth or Seventh Fleet operations are handled through NAS Sigonella's comptroller department.

The flight hour data sources were previously mentioned in this chapter. However, there are some facts that affect the development of budgetability measures. First, the flight hours for the Atlantic Fleet (HSL-42, -44, -46, -48) squadrons, obtained from the 3-M Aviation Individual Aircraft History Summary (NAMSO 4790.A7166-01), were divided into total hours flown and total at-sea hours flown. There was no differentiation in the at-sea flight hours as to under which fleet (Second, Sixth or Seventh) they were flown. This hourly total subtracted from the total flight hours flown resulted in the number of hours flown in support of Atlantic and Second Fleet operations. This gave a denominator that corresponded to the Atlantic Fleet AFM figures received from the NS Mayport comptroller.

An attempt was made to determine the quantity of at-sea flight hours flown. HSLWLANT, the East Coast wing,

attempted to verify the deployment dates and locations for each squadron's detachments for the period from January 1991 to December 1992. However, this proved to be impossible. This proved to be an insurmountable block in the development of budgetability measures.

B. TECHNIQUES OF ANALYSIS

In the analysis of the data, three statistical tests were employed, and the results of which are summarized in Appendix C. The first test used was the Analysis of Variance (ANOVA)[6] test. All squadrons were analyzed together and an F-statistic was generated. With a probability level of five percent, an F-statistic greater than 1.88 suggests that at least two of the squadron means were significantly different than the rest. In the case of every measure analyzed, the observed F-statistic was greater than the threshold level. This indicated that each of the squadron means observed could not be used to make inferences about the population.

The second test performed was a small-sample hypothesis test for two population means. Each squadron, with 24 observations, was compared to the entire group, with 231 observations, in an attempt to determine if the squadron mean was significantly different from the entire group mean. In

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[6] An ANOVA is a test used to make inferences about the means of several populations. [Neil A. Weiss and Matthew J. Hassett, *Introductory Statistics, Third Edition*, Addison-Wesley Publishing Co. Reading, MA, 1991, p. 705]

each case, a t-score was developed and a 5 percent probability level was used. The results are summarized in Appendix C. If the t-score exceeded the score associated with the confidence level, then the squadron's mean was different than the group's mean. The magnitude of the t-score also inferred the magnitude of the difference.

In an effort to determine if a significant difference existed between specific groups of activities, the third test conducted was a large-sample hypothesis test for two population means. Three tests were performed: fleet replacement squadrons (FRS) vs. all deployable squadrons (Sea); all Atlantic Fleet squadrons (LANT) vs. all Pacific Fleet squadrons (PAC); and all Atlantic Fleet deployable squadrons (LANT-Sea) vs. all Pacific Fleet deployable squadrons (PAC-Sea). In each test, a z-score was developed and compared to the z-score for a five percent probability level. If the observed z-score exceeded 1.645, the two populations were determined to be significantly different.

The basic analysis techniques as discussed above were attempted for the budgetability measures. In addition, a linear regression technique was attempted on each different activity in an effort to determine the extent to which AFM was dependent upon flight hours flown. The intent was to determine if there is some portion of the AFM expenditure that might be considered a fixed cost required by each squadron independent of flight hours. Provided that a strong linear

relationship existed, the regression line, and corresponding equation, would provide an AFM budget target for the squadron.

In conducting this analysis, the actual AFM expenditures were regressed against flight hours flown to determine the strength of the relationship between these two figures and to determine a formula for the resulting regression line. However, the data received was significantly flawed and thus unsuitable for any budgetability measure analysis.

C. INTERVIEWS WITH THE SQUADRON AND WING MAINTENANCE OFFICERS

Seven squadron and two wing Maintenance Officers were given structured interviews in conjunction with this thesis. The interviews attempted to determine the respondent's definition of readiness, awareness of the seven performance improvement elements and definition for each, and the impact of AFM funding on their maintenance efforts. As part of the interview, each respondent was asked to rank and weigh each of the seven performance improvement elements. The results of these interviews were analyzed and used to create the alternative measures of performance.

D. MEASURES OF EFFECTIVENESS

As defined previously, effectiveness is the degree to which the system produces the right things according to the correct specifications within the allotted time constraints. In terms of aviation maintenance, effectiveness implies that

all the work scheduled was performed, the work was completed according to the applicable instructions, and the aircraft was available to fly. In essence, all of the material condition statistics (FMC/PMC/NMC) are effectiveness measures. In addition, flight hours flown can also be considered a measure of effectiveness. Actual flight hours is output and any measure of actual output provides some statistic about how effectively the system operates.

However, these measures are not a measure of overall performance. This becomes evident when all of the different performance measures are viewed in relation to MC. The level of variance between the squadrons for each statistic is quite large. If these activities all have the same type aircraft, similar work forces and similar organizational structures, the variances between the units should be relatively small. Based on the data gathered from the maintenance data reporting system, six alternative performance measures can help monitor and measure effectiveness in maintenance.

1. Mission Capability (MC) Percentage

Mission Capability (MC) is defined as the "material condition of an aircraft that can perform at least one and potentially all of its missions." [Ref. 11: p. 3] Mission capability is calculated by subtracting NMC hours from Element in Service (EIS) hours and dividing the result by EIS hours. Mission Capability is a measure that is currently

employed to measure overall performance of the maintenance department. However, in light of the aforementioned effectiveness definition, the percentage of time that an aircraft is MC is a measure of effectiveness.

2. Optimum Capability Percentage

The Optimum Capability Percentage should not be confused with the Optimum Performance Capability[7] indicator. The Optimum Capability Percentage is determined by subtracting all NMCM and PMCM hours from EIS hours and dividing the result by total EIS hours. This statistic represents the maximum potential time the aircraft could be mission capable assuming that supply delays do not exist. The closer the resulting figure is to 100 percent, the more effective the maintenance effort.

3. Mission Capability/Optimum Capability (MC/OC) Ratio

The MC/OC ratio can be calculated by dividing the MC percentage by the OC percentage. This is an output measure that suggests the effectiveness of the maintenance effort by determining how close the MC rate achieved by the squadron meets the Optimum Capability Percentage. The closer this

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[7] Optimum Performance Capability is the "maximum capability for successful completion on all assigned missions, through the availability of all equipments, within the mission capabilities of an aircraft or training device." [Ref. 2: p. C-21] It is determined by subtracting all NMC, PMC, FMCM, and FMCS hours from the total EIS hours and dividing the result by total EIS hours.

statistic comes to 100 percent, the more effective the maintenance department.

4. Flight Hour Execution Ratio

The Flight Hour Execution Ratio is flight hours flown divided by flight hours scheduled. Flight hours scheduled is the flight hour allocation granted at the beginning of the quarter or month. The number of flight hours granted to each squadron was not available for analysis.

5. Sortie Execution Ratio

The Sortie Execution Ratio is the number of flights actually flown divided by the number of flights scheduled. By adding flights flown and number of aborts the total number of flights scheduled can be approximated. However, this statistic fails to include the number of flights scheduled by the squadron's operations department but were never attempted. The number of flights canceled by each squadron was not available.

6. Utilization Rate

Utilization Rate is defined as total flight hours flown divided by total hours available to fly. Total hours available to fly is determined by subtracting all NMC hours from EIS hours. This measure can be determined from the Monthly Equipment Discrepancy and Utilization Report (SCIR-3). This is an output measure describing the quantity of time that the aircraft flew in relation to the number of hours it was

available to fly. A higher utilization rate reflects that an aircraft is for a greater portion of its available time. This might suggest a less effective maintenance effort because, in order to meet the squadron's allotment of flight hours, the aircraft had to be utilized more. A low utilization rate might suggest a more effective maintenance effort because the squadron was able to meet its flight hour commitment without over-utilizing the aircraft. In addition, the utilization rate for a particular aircraft can be compared against the rate for the entire squadron to determine the effectiveness of the maintenance performed on that particular aircraft.

E. MEASURES OF EFFICIENCY

Efficiency was defined previously as the resources expected to be consumed compared to the resources actually consumed. Within aviation maintenance there are two basic resources: labor and money. Labor resources are the man-hours available for use in repairing aircraft. The financial resources are used to purchase parts and support material. Because cannibalization was discussed by several maintenance officers in the interviews as an efficiency concern, statistics concerning cannibalization will be discussed in this section.

1. Labor Measures

The research uncovered the following seven alternative performance measures for determining the efficiency of labor use. The statistics and frequency curves are intended to highlight the difference in observed, historical figures, and not to evaluate the efficiency of any squadron's maintenance effort.

a. Labor Utilization Rate (LUR)

The Labor Utilization Rate (LUR) reflects the extent to which labor was used throughout the period. LUR is the ratio of total man-hours expended for the period divided by the standard number of labor hours available for the period. The total number of man-hours can be determined from the Maintenance Action by Bureau/Serial Number Report (MDR-5). The standard number of labor hours available is calculated by multiplying the hours available for work, as set forth in the Navy Standard Workweek, [Ref. 12: p. 5-17] by the total number of direct maintenance personnel and the number of weeks in the period. An activity that has a LUR of less than 1.0 has a more productive labor force than an activity that has a LUR of greater than 1.0. Because of limitations in the research for this thesis, the data for this statistic was not obtained.

b. Labor Usage Rate

The Labor Usage Rate is determined by dividing the total direct maintenance man-hours by the number of hours available for productive work for a day. The hours available for productive work are derived by dividing the workweek productive hours from the Navy Standard Workweek [Ref. 11: p. 5-17] by five days (33.38 ÷ 5 = 6.676 hours per day). The result is the number of man-days worked by the squadron. The lower the man-days, the more effective the maintenance effort.

When a detachment is at sea, the hours available for productive work increases to 60 hours per week. [Ref 11: p. 5-18] This equates to almost nine ashore man-days for every week at sea. Since the actual number of man-days was undeterminable within the limitations of this thesis, the at-sea man-days were assumed to be equal between squadrons, and thus have little significant effect on the Labor Usage Rate statistic. However, this assumption seriously impairs the diagnostic ability of this statistic within the context of this thesis.

c. Maintenance Man-Hour (MMH) Ratio

Maintenance Man-Hour Ratio can be determined by comparing two different categories of maintenance: unscheduled and scheduled. Unscheduled maintenance is "maintenance, other than the fix phase of scheduled maintenance, occurring during the interval between scheduled

downtime maintenance periods."[Ref. 2: p. C-36] Unscheduled maintenance man-hours can be found on the Special Flight Summary Report (NAMSO 4790.A7166-01).

Scheduled maintenance consists of "periodic prescribed inspection/servicing of equipment, done on a calendar, mileage, or hours of operation basis."[Ref. 2: p. C-30] Scheduled maintenance man-hours can be found on the Special Flight Summary Report (NAMSO 4790.A7166-01).

The ratio of unscheduled maintenance man-hours expended to scheduled man-hours expended for the period describes the relationship between emergent maintenance actions and preventative maintenance. A ratio that is greater than 1.0 indicates that the unit is devoting more time to unscheduled maintenance than scheduled maintenance. Considering that preventative maintenance is pro-active, and that unscheduled maintenance is emergent and of higher priority, the degree to which scheduled maintenance exceeds unscheduled maintenance (a ratio less than 1.0) suggests a level of efficiency in the maintenance effort.

d. Scheduled Direct Man-Hour (SDMH) Percentage

The Scheduled Direct Man-Hour Percentage provides a picture of the proportion of all direct maintenance man-hours for the period devoted to scheduled maintenance. The statistic is determined by dividing scheduled man-hours by total direct maintenance man-hours. Because scheduled

maintenance is essentially a preventative measure, the higher this percentage, the more that labor resources are devoted to efficient maintenance.

e. Unscheduled Direct Man-Hour (UDMH) Percentage

The Unscheduled Direct Man-Hour Percentage (UDMH) depicts the portion of total direct maintenance man-hours devoted to unscheduled maintenance. UDMH is determined by dividing all of the man-hours directed at unscheduled maintenance by the total number of man-hours recorded for the period. Unscheduled maintenance is emergent and usually of higher priority, and so, the lower this percentage, the less of the "labor pie" consumed by these activities.

f. SCIR-Maintenance Ratio

The SCIR-Maintenance Ratio measures the accumulated number of hours that maintenance discrepancies were recorded against the aircraft and the number of direct man-hours devoted to remedying those discrepancies. It is calculated by dividing the SCIR hours due to maintenance (SCIR-M) by the total direct man-hours. This statistic is unique in that it captures all of the Awaiting Maintenance (AWM) hours that are logged against the aircraft for the month. The lower the result, the quicker the maintenance activity was at addressing the discrepancy and minimizing their AWM time.

g. Total Man-Hour Coverage Ratio

Total Man-Hour Coverage Ratio is calculated by dividing the total direct man-hours recorded by the sum of the NMCM and PMCM hours (TMH/(NMCM+PMCM)). This figure shows the number of man-hours expended per hour of mission degradation. A high result for this metric indicates that the squadron is more effective at managing the time the aircraft is degraded for maintenance by repairing the malfunction and devoting the limited labor resource to other priorities.

h. Maintenance Man-Hours per Maintenance Action

Maintenance Man-Hours Per Maintenance Action (MMH/MA) is defined as the average number of man-hours required to complete a maintenance action. It is understood that some maintenance actions require many more man-hours than others. In the aggregate, This is still a valid measure of the efficiency of the maintenance effort, because a lower figure reflects that fewer maintenance hours are required to complete a maintenance action.

MMH/MA can be determined from the Maintenance Action by Bureau/Serial Number Report (MDR-5). MMH/MA is derived by dividing Man-Hours Organizational by Items Processed Organizational. This can be done for each aircraft and the squadron as a whole.

2. Cannibalization

The NAMP states that "the reduction or elimination of cannibalization should be of prime concern to management." [Ref. 7: p. 4-7] Cannibalization, as defined previously, is the removal of a part from one aircraft for installation on another. While a significant factor determining the amount of cannibalization might be a lack of available parts in the supply system, it can be convincingly argued that the act of cannibalization, regardless of the reason, is outside the bounds of standard procedure. This does not imply that cannibalization is unsafe, but, more to the point, that cannibalization is an inefficient maintenance practice because of the waste of manpower required to remove the part from one aircraft and install it on another. In addition, there is increased wear being placed on the part being removed and reinstalled. In the rare case that the cannibalized aircraft is flyable, there is the additional loss of mission functions to be considered. All cannibalization figures are measures of effectiveness because the greater the number of man-hours used in cannibalizing, the fewer man-hours that are directed at repairing aircraft. Some might argue that there is repair work being completed if an aircraft is returned to a flyable condition. Regardless of how many aircraft are flying due to cannibalization, the malfunction remains and man-hours will still have to be expended to repair the aircraft that was "robbed."

Cannibalization measures are one of the few measures in use by all of the squadrons surveyed. A Cannibalization Trend and/or Cannibalizations per 100 Flight Hours was included in the internal report generated each month. Along with Cannibalizations per 100 Flight Hours, two other possible performance improvement measures concerning cannibalization will be discussed and analyzed.

a. Cannibalization Man-Hours Percentage

Cannibalization Man-Hours Percentage is a statistic that depicts the percentage of man-hours expended for cannibalization as a percentage of all man-hours recorded. To determine the percentage, the number of man-hours devoted to cannibalization is divided by the total number of man-hours expended during the month. This measures effectiveness by determining what percentage of the total direct maintenance man-hours are directed toward a non-value added activity.

b. Cannibalization Items Percentage

A cannibalization items percentage can be determined from the No Defect Report (MDR-12). The total of all items with an action (AT) code T, maintenance actions involving cannibalization, is divided by the total maintenance actions processed by the entire organization for the month, found on the Monthly Production Report (MDR-2).[Ref. 7: p. 4-7] This statistic is similar to the previous measure, except

that it views the percentage of maintenance actions that did not contribute to repairing aircraft.

c. Cannibalization Items per 100 Flight Hours

This statistic is determined by dividing the number of items cannibalized by a divisor that is the result of the total flight hours divided by 100. This suggests that the number of cannibalizations are in some way dependent upon the number of flight hours flown. This measure is currently employed by many of the squadrons in their monthly maintenance summary.

F. MEASURES OF QUALITY

Quality was defined in Chapter III as "the degree to which the system conforms to requirements, specifications, or expectations." [Ref. 9: p. 43] Performance measures that gauge quality address the degree to which the outputs of the organization met the needs of the customer or the specifications established. This study identified seven possible quality measures for evaluating maintenance efforts. It is suggested that further research be conducted to develop better reporting criteria and more adequate metrics for gauging this performance element.

1. No Repair Items

The ratio of items that do not require any repair action compared to the total number of items repaired by the intermediate maintenance activity (IMA) is an indicator of the

effectiveness of a unit's maintenance effort. The higher the ratio, the more items are being sent to the IMA that do not require any action. The more effective a squadron's maintenance effort, the smaller this percentage. This information can be found on the Component Repair/Beyond Capability of Maintenance Report (MDR-7).

2. Documentation Error Rate

The Documentation Error Rate is determined by dividing the total number of VIDS/MAFs submitted during the reporting period by the number of VIDS/MAFs containing errors. This is a very distant performance measure of the quality of the actual maintenance activity, but it is an excellent measure of the quality of paperwork that is being produced. This measure is currently used and reported in the squadron's 3-M Monthly Maintenance Summary.

3. Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) represents the total flight hours divided by the total number of maintenance actions. Total flight hours can be determined from the Monthly Equipment Discrepancy and Unitization Report (SCIR-3) and the number of maintenance actions can be garnered from the Maintenance Action by Bureau/Serial Number Report (MDR-5). This statistic can be determined for each aircraft and for the squadron as a whole.

MTBF is a surrogate measure of quality because it measures a factor that represents quality of maintenance practices. The more flight hours that can be flown between maintenance actions, suggests that higher quality maintenance is being performed.

4. Corrosion Control Ratio

The Corrosion Control Ratio is expressed as the total corrosion control man-hours as a percentage of total direct man-hours expended. The total corrosion control hours can be determined from the Corrosion Control/Treatment Report (MDR-11). The total number of man-hours expended can be garnered from the Maintenance Action by Bureau/Serial Number Report (MDR-5).

Corrosion control is the most significant form of preventative maintenance performed by a maintenance activity. It is one of the measures that is tracked by all of the squadrons on a monthly basis. The greater amount of time allotted to preventative maintenance, the less likely that malfunctions will occur. Therefore, the Corrosion Control Ratio is an indirect measure of the quality of the maintenance effort.

5. Corrosion Control to Flight Hours Ratio

The man-hours expended toward corrosion control divided by the number of flight hours flown gives the Corrosion Control to Flight Hour Ratio. This measure infers

that the more corrosion control hours logged for every flight hour, the higher the quality of maintenance.

6. Functional Check Flight (FCF) Ratio

The FCF Ratio is the result when total functional check flight hours are divided by the number of FCFs completed. The assumption is that the better the quality of the maintenance performed, the fewer number of flight hours required to complete an FCF. Included in this measure is an indicator of the quality of the training of the maintenance personnel who are operating the specialized vibration equipment, if it is installed.

7. Unscheduled Man-Hour Ratio

The Unscheduled Man-Hour Ratio can be determined by dividing the number of unscheduled maintenance man-hours devoted to repair maintenance (UMH less cannibalization man-hours) by the total number of unscheduled maintenance man-hours. This statistic depicts the percentage of unscheduled man-hours that are employed in the correction of discrepancies, and views any man-hours devoted to cannibalization as a reduction in the quality of the maintenance performed.

G. MEASURES OF PRODUCTIVITY

As noted in Chapter II, the NAMP defines productivity as the relationship between the outputs created by a system and

the inputs required to achieve those outputs. [Ref. 2: p. 2-1] This study analyzed four alternative measures of productivity.

1. Total Man-Hour/Flight Hour Ratio

Total direct maintenance man-hours divided by the total of flight hours flown for the period gives the Total Man-Hours/Flight Hour ratio. This statistic depicts the number of direct maintenance man-hours used for every flight hour flown. In the case of this measure, the lower the resulting statistic, the more productive the maintenance department.

2. Scheduled Man-Hour/Flight Hour Ratio

The Scheduled Man-Hour/Flight Hour Ratio is the result of dividing scheduled direct maintenance man-hours by total flight hours. This ratio depicts the number of scheduled direct maintenance man-hours employed to achieve one flight hour. As with the Total Man-Hour/Flight Hour Ratio, a lower score on this measure indicates that fewer scheduled man-hours are being expended per flight hour. With this statistic, there should be a strong association between scheduled maintenance hours and flight hours because a large portion of scheduled maintenance is determined by flight hours. This relationship is due to certain maintenance is scheduled on a flight hour basis.

3. Unscheduled Man-Hour/Flight Hour Ratio

The Unscheduled Man-Hours/Flight Hour Ratio describes the number of unscheduled direct maintenance man-hours used for each hour the aircraft is flown. This statistic is determined by dividing the total unscheduled direct maintenance man-hours by the total flight hours flown during the period. As with the two previous measures, the lower the result, the better the productivity. This statistic also gives a picture of the number of unscheduled man-hour needed to support an hour of flight operations.

4. Total Flight Hour/Total Man-Hour Ratio

Total flight hours divided by total man-hours illustrates the Total Flight Hour/Total Man-Hour Ratio. This ratio is the inverse of the Total Man-Hour/Flight Hour Ratio. It calculates the number of flight hours flown for every man-hour consumed. The more productive a maintenance department, the higher this statistic.

H. MEASURES OF BUDGETABILITY, QUALITY OF WORK LIFE, AND INNOVATION

Budgetability refers to the relationship between the actual expenses incurred to maintain the aircraft and the budgeted amount for the same period. Within the context of the organizational-level aviation maintenance department, this element is primarily concerned with Aviation Fleet Maintenance funds (AFM). Within this performance improvement element, two

performance measures are suggested. The cost per flight hour is currently used, but it essentially applies to the budgeting process. Information that would have facilitated analysis of budgetability measures was highly flawed, therefore the analysis of these measures was not performed.

1. Cost per Flight Hour (AFM/FH)

Cost per Flight Hour is developed by dividing the total cost of parts and materials for the period by the flight hours flown for the period. This measure provides a metric for determining the cost in parts for each flight hour flown. The cost of parts can be garnered from the material control department in each squadron. The Cost per Flight Hour figure is then compared with the budgeted cost per flight hour for the period.

2. Cost per Maintenance Action (AFM/MA)

The Cost per Maintenance Action (AFM/MA) is developed by dividing the cost of parts and materials by the total fight hours flown for the period. This measure depicts the average cost of each maintenance action. The cost figure is the same as for the Cost per Flight Hour (AFM/FH) and the maintenance action figure can be determined from the Maintenance Action by Bureau/Serial Number Report (MDR-5).

The best measure of the Quality of Work Life would be a survey quantifying the perceptions of the maintenance personnel involved in the system. Because of the subjectivity

of this measure and the time limitations for this study, developing a Quality of Work Life measure was determined to be beyond the scope of this thesis.

Possible measures of innovation might be the number of Technical Publication Deficiency Reports (TPDRs), Quality Deficiency Reports (QDRs) or Engineering Investigations (EIs). However, because of difficulty in obtaining this data and the time constraints, innovation measures were not developed.

I. SUMMARY

This chapter commenced with a description of the sources for the data used in the analysis of the alternative performance measures. The statistical methods and processes used to analyze the performance measures were detailed. Alternative performance measures were suggested for five of the seven performance improvement elements. The next chapter will provide analysis on 23 of the suggested performance measures within the context of four of the performance improvement elements. The performance measures that will be analyzed are summarized in Figure 17.

Effectiveness Measures
- Mission Capability Percentage
- Optimum Capability Percentage
- Mission Capability/Optimum Capability Percentage
- Sortie Execution Ratio
- Utilization Ratio

Efficiency Measures
- Labor Utilization Rate
- Maintenance Man-Hour Ratio
- Scheduled Direct Man-Hour Percentage
- Unscheduled Direct Man-Hour Percentage
- SCIR-Maintenance Ratio
- Total Man-Hour Coverage Ratio
- Maintenance Man-Hour/Maintenance Action
- Cannibalization Man-Hour Percentage
- Cannibalization Items Percentage
- Cannibalization Items per 100 Flight Hours

Quality Measures
- Mean Time Between Failures
- Corrosion Control Ratio
- Corrosion Control to Flight Hour Ratio
- Unscheduled Man-Hour Ratio

Productivity Measures
- Total Direct Man-Hour/Flight Hour Ratio
- Scheduled Direct Man-Hour/Flight Hour Ratio
- Unscheduled Direct Man-Hour/Flight Hour Ratio
- Total Flight Hour/Total Man-Hour Ratio

Figure 17 Performance Measures to be Analyzed

V. DATA PRESENTATION

In Chapter IV, several performance measures were described and discussed within the umbrella of each performance improvement element. In this chapter, the performance measures will be analyzed with the tests described in the previous chapter. The results of the statistical tests conducted are included in Appendix C.

The analysis of the historical data for each measure is intended to highlight differences existing between the squadrons surveyed. The analysis is not an attempt to pronounce judgement on any squadron or its specific maintenance practices. The evaluation of the measure, and any causality determination, is to be made by the individual squadron within the context of its performance improvement program.

A. ANALYSIS

To illustrate the character of the observations, frequency distributions were generated on every performance measure for which data was available. For the majority of the measures, two graphs were compiled. The first depicts the distribution for all of the observations as a single group and is included in this chapter. The second graph highlights the FRS, LANT-

Sea, and PAC-Sea groups and is located in Appendix D. For several of the measures, a highlighted graph is included in this chapter to further amplify a specific area of the distribution. The highlights of the statistical tests are co-located with the frequency distribution of all observations. An asterisk (*) after a test score indicates that the result is statistically significant at a five percent probability level.

B. EFFECTIVENESS

1. Mission Capability (MC) Percentage

The frequency distributions of Mission Capability are in Figure 18 for all LAMPS squadrons. The observed mean for all LAMPS squadrons was 71.30 percent, which is less that the Mission Capable goal of 77 percent established in the MESM [Ref. 10: p. 3]. The F-statistic indicated that there was significance between the means of the squadrons. The t-scores indicated that six of ten squadron means were significantly different from the entire population. However, only one of those means was dramatically different, exceeding the group mean by almost 14 percent. Another squadron's mean significant difference might be attributed to the fact that it was a new squadron and received its first aircraft in October of 1991. The Mission Capability statistics on the breakout groups indicated that there was a significant difference

between LANT-Sea and PAC-Sea, with LANT-Sea reporting a greater MC percentage.

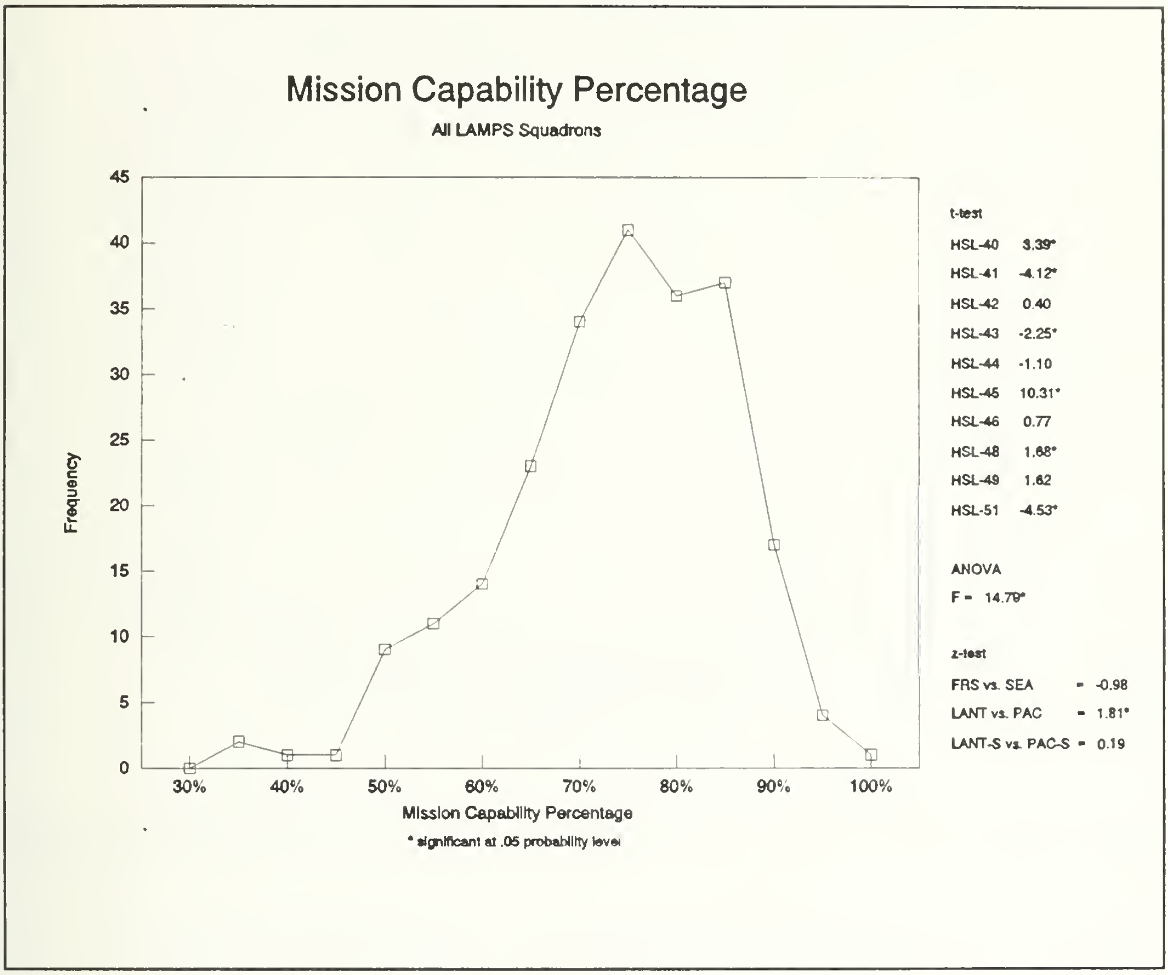

Figure 18

2. Optimum Capability Percentage

Figure 19 displays the distribution of the observed frequency curve for all squadrons. The ANOVA test generated an F-statistic of 18.07 and eight of the ten squadrons' t-scores exceeded the confidence level threshold. It should be noted that for all of the effectiveness measures analyzed, OC

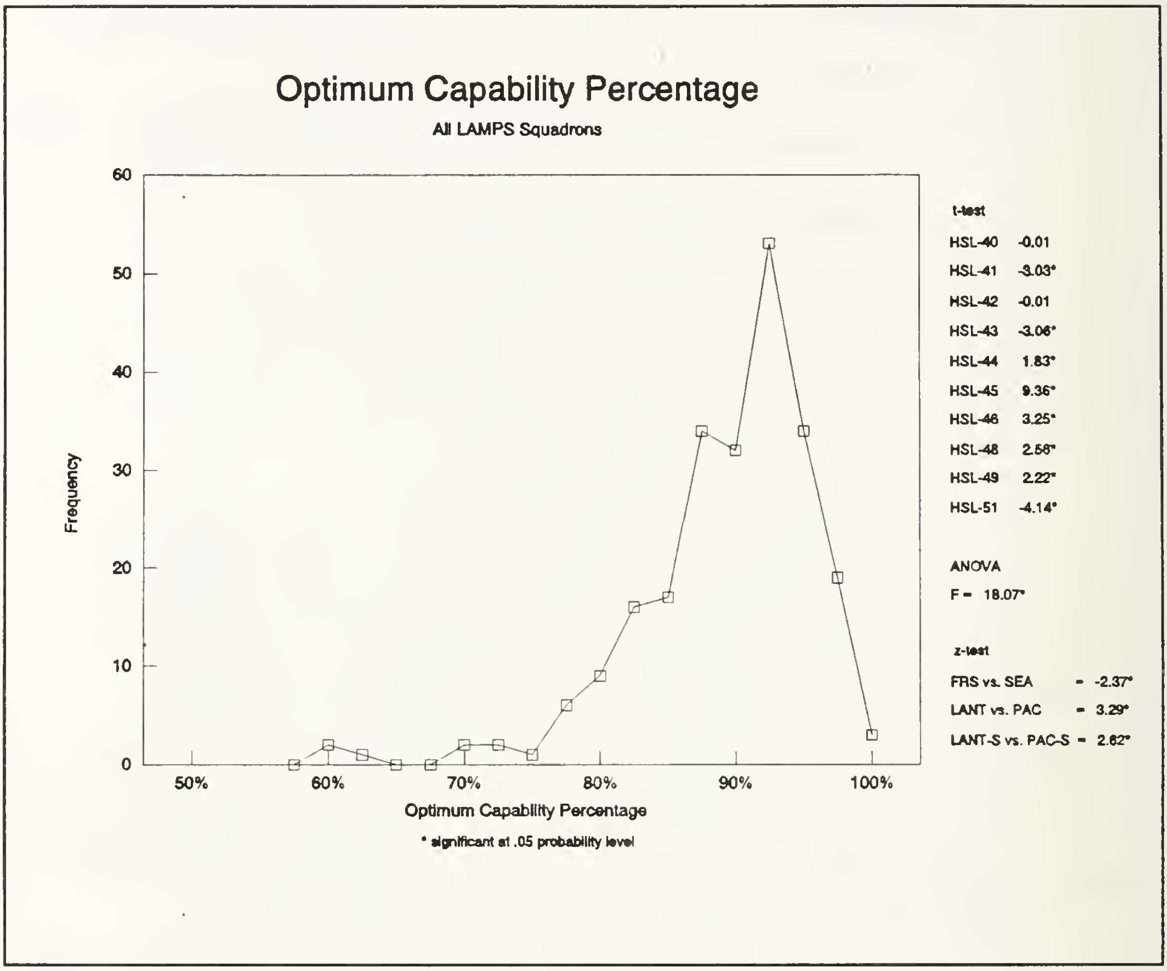

Figure 19

displayed the highest F-statistic. In addition, each of the activity groups displayed a significant z-score.

The OC standard deviations are noticeably smaller than the MC standard deviations for each of the squadrons surveyed. This suggests a smaller dispersion in this measure than is observed in the MC figure.

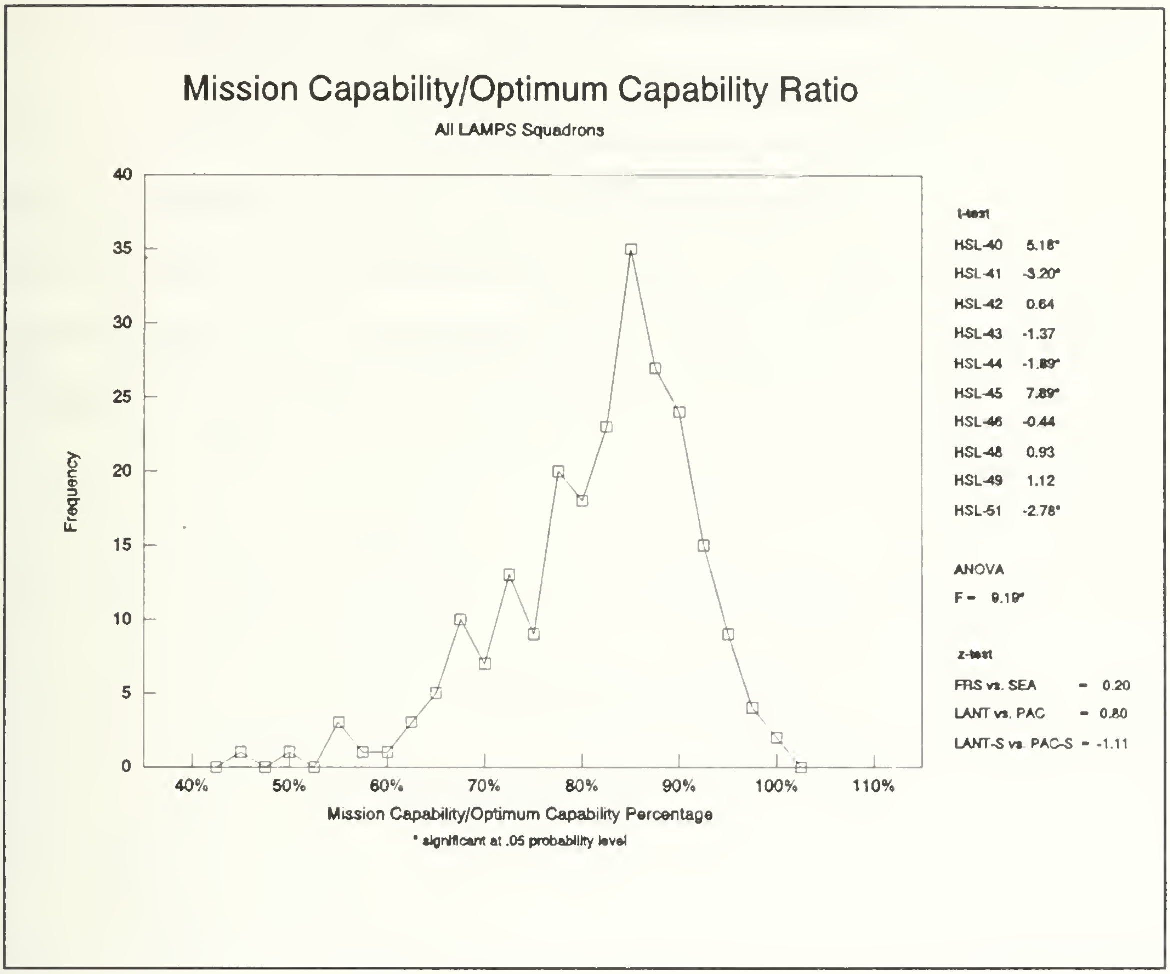

Figure 20

3. Mission Capability/Optimum Capability (MC/OC) Ratio

Figure 20 depicts a frequency distribution that approaches a normal curve. The curve depicts a normal distribution that is centered around a mean of 80.59 percent.

With an F-statistic of 9.19, analysis of the MC/OC ratio showed that the means of the squadrons were significantly different. However, two of the squadrons with high t-scores were markedly different on the positive side.

The activity group z-scores showed that no distinction could be made between the separate groups.

4. Sortie Execution Ratio

The distribution for all of the LAMPS squadrons can be found in Figure 21. The mean for the distribution in Figure 21 is 93.35 percent. This indicates that slightly more than six percent of the flights attempted are being aborted

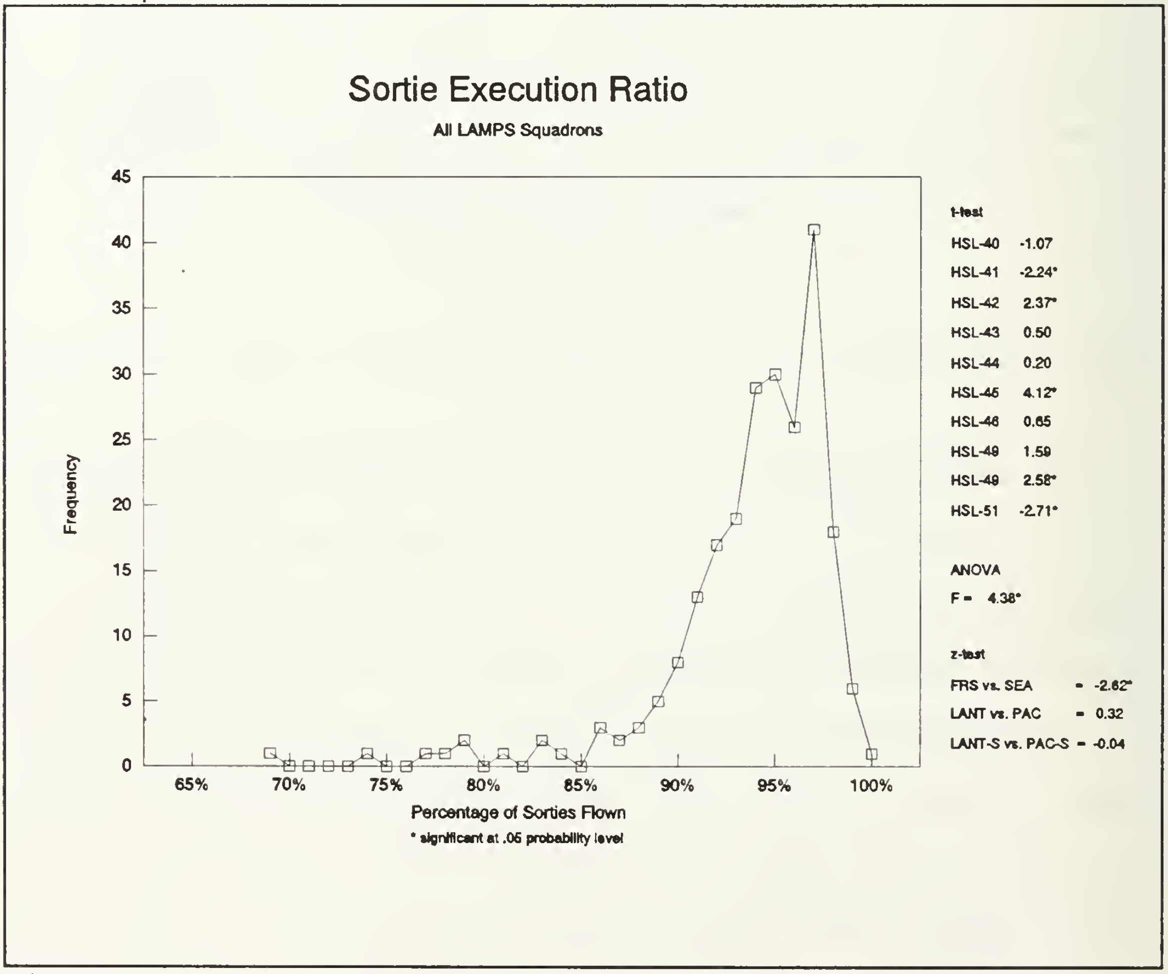

Figure 21

due to maintenance problems. The highlighted Sortie Execution shows a normal distribution around the mean of 93.35 percent. The F-statistic for the Sortie Execution Ratio of 4.38 was the lowest observed for all of the effectiveness measures. The FRS vs. SEA test registered a z-score of negative 2.62. That score exceeded the threshold and indicated that the FRS's logged more aborted flights than the remainder of the fleet.

Examination of the t-scores and the standard deviation of each squadron suggests a distribution with a small spread. Further evidence of this comes from the majority of the data points falling between 90 percent and 100 percent, as seen in Figure 64 of Appendix D. However, it is highly probable that this distribution would increase its dispersion if the number of flights canceled was included in the denominator.

5. Utilization Rate

Figure 22 displays the frequency curve for utilization rates for all squadrons. This curve depicts a well defined normal curve with a mean of 10.47 percent. Utilization rates in excess of 12 percent are rather remarkable, considering that the aircraft for those squadrons flew one in every eight hours the aircraft was available to fly.

The two FRSs have significantly lower utilization rates than the rest of the fleet, with a z-score exceeding the threshold by almost eight points (-10.3038 to 1.645). The z-scores of the LANT vs. PAC and LANT-Sea and PAC-Sea barely

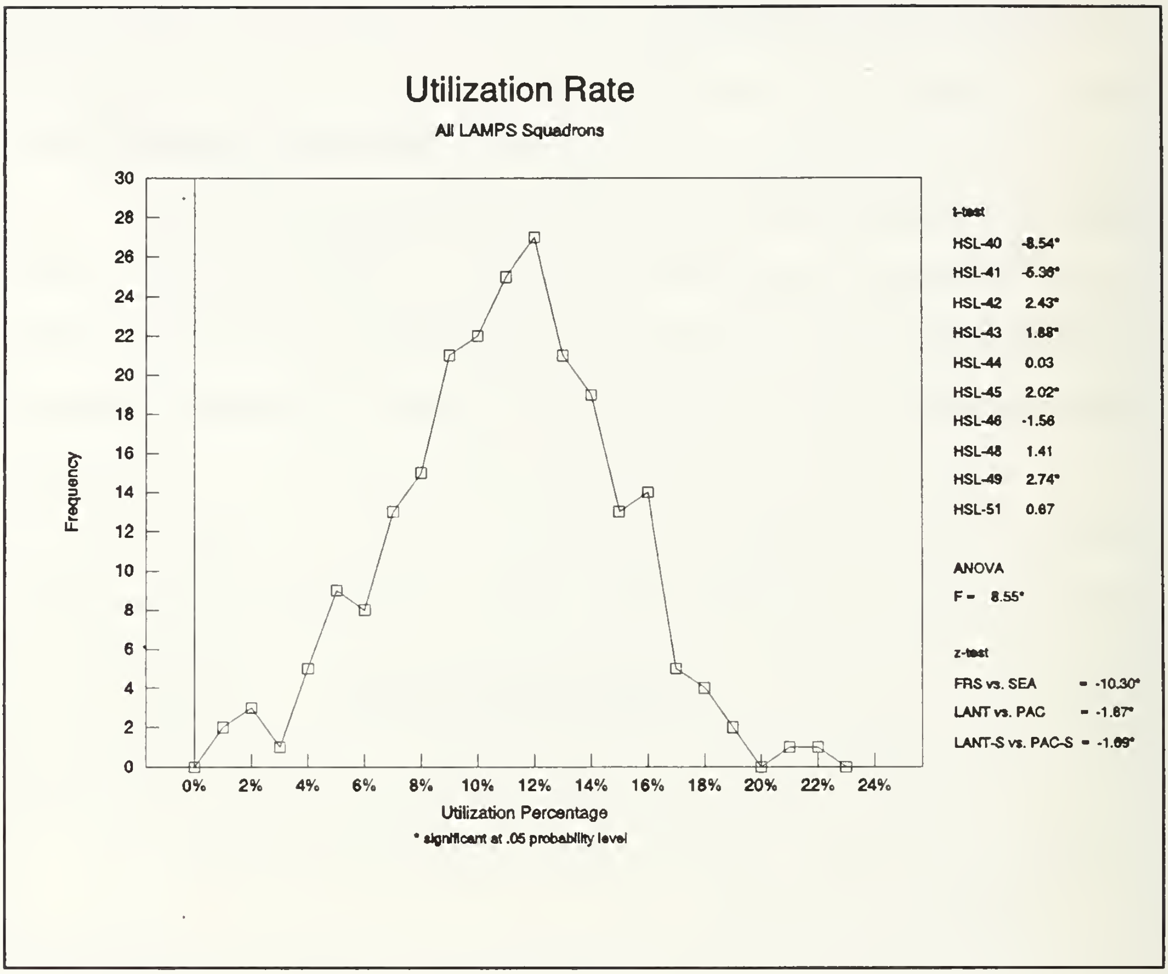

Figure 22

clear the 95 percent confidence level threshold. The F-statistic of 8.55 indicates that the squadron means are different. The t-statistic shows a fairly tight grouping for the squadron means. However, five of the ten squadron means exceeded the required threshold.

C. EFFICIENCY

1. Labor Usage Rate

Figure 23 displays the Labor Usage Rate frequency curve for all of the LAMPS squadrons. The mean of this normal curve is 954.3 man-days. The curve also appears to approach a normal curve.

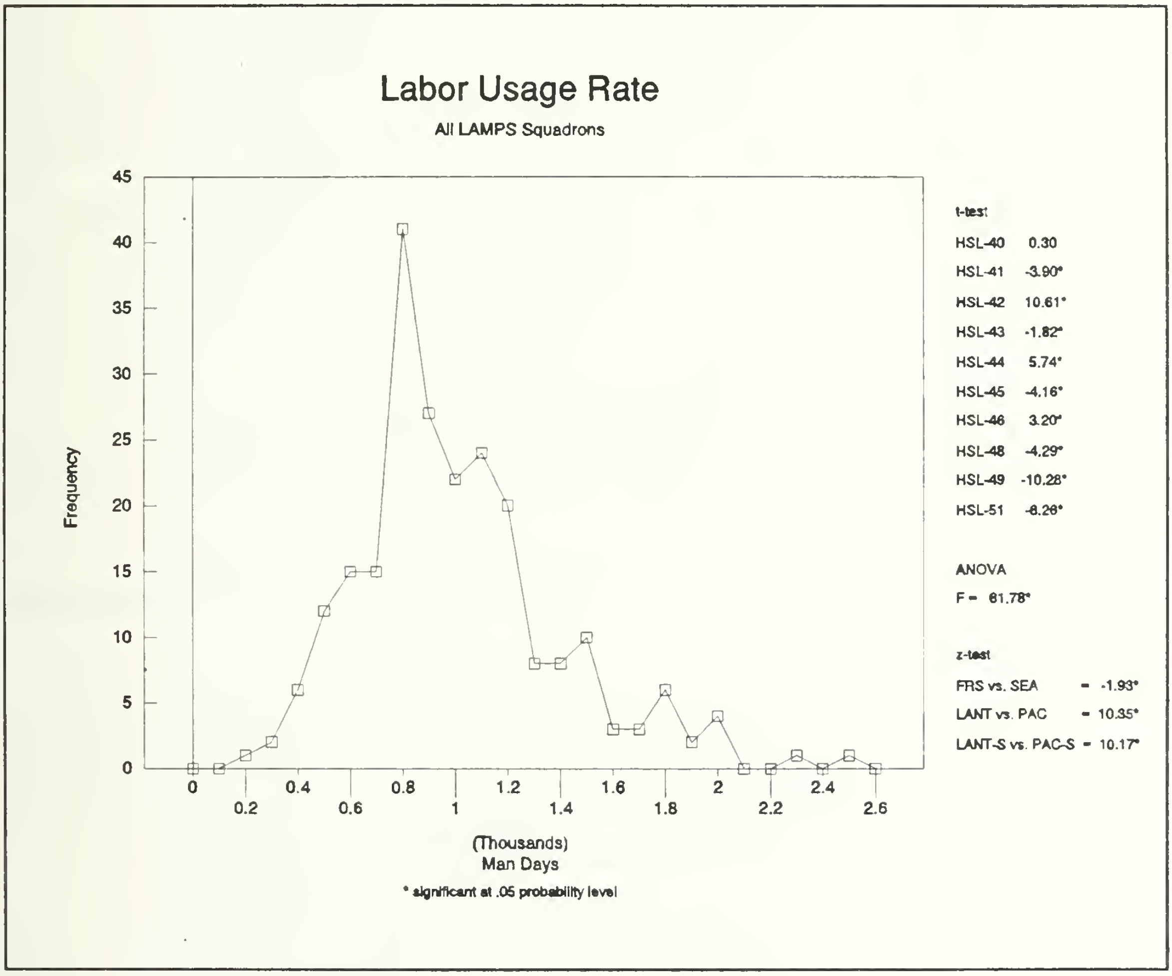

Figure 23

The ANOVA, with an F-statistic of 61.78, determined that the squadrons were significantly differentiated. The test between the FRS and SEA groups showed the FRS

significantly lower than the deploying squadrons. However, there was a significant difference between the LANT and LANT-Sea when tested against PAC and PAC-Sea respectively. The LANT mean was 1158.9 man-days compared to the PAC squadron's mean of 733.2 man-days. In addition, the LANT-Sea yielded a mean of 1206.8 man-days and PAC-Sea had a mean of 712.0 man-days. In both cases, the z-score exceeded ten. This indicated that there exists a significant difference between the Atlantic and Pacific Fleet units in the number of man-days used during a month. The t-scores of the squadrons showed a highly dispersed population, with specific scores ranging from 10.61 to negative 10.28.

2. Maintenance Man-Hour (MMH) Ratio

Figure 24 graphically displays the ratio for all LAMPS squadrons from January 1991 to December 1992. The curve is centered around a mean of 0.62 unscheduled man-hours per scheduled man-hour.

There was a large variation in the observed means of the squadrons. This was evidenced by nine of the squadron means exceeded the 95 percent confidence level, and an F-statistic of 50.07. All of the activity tests yielded a z-score in excess of the five percent probability level. The level to which the LANT activities scored lower than the PAC activities was very significant. All of the Atlantic Fleet units yielded a negative t-score which indicated that these

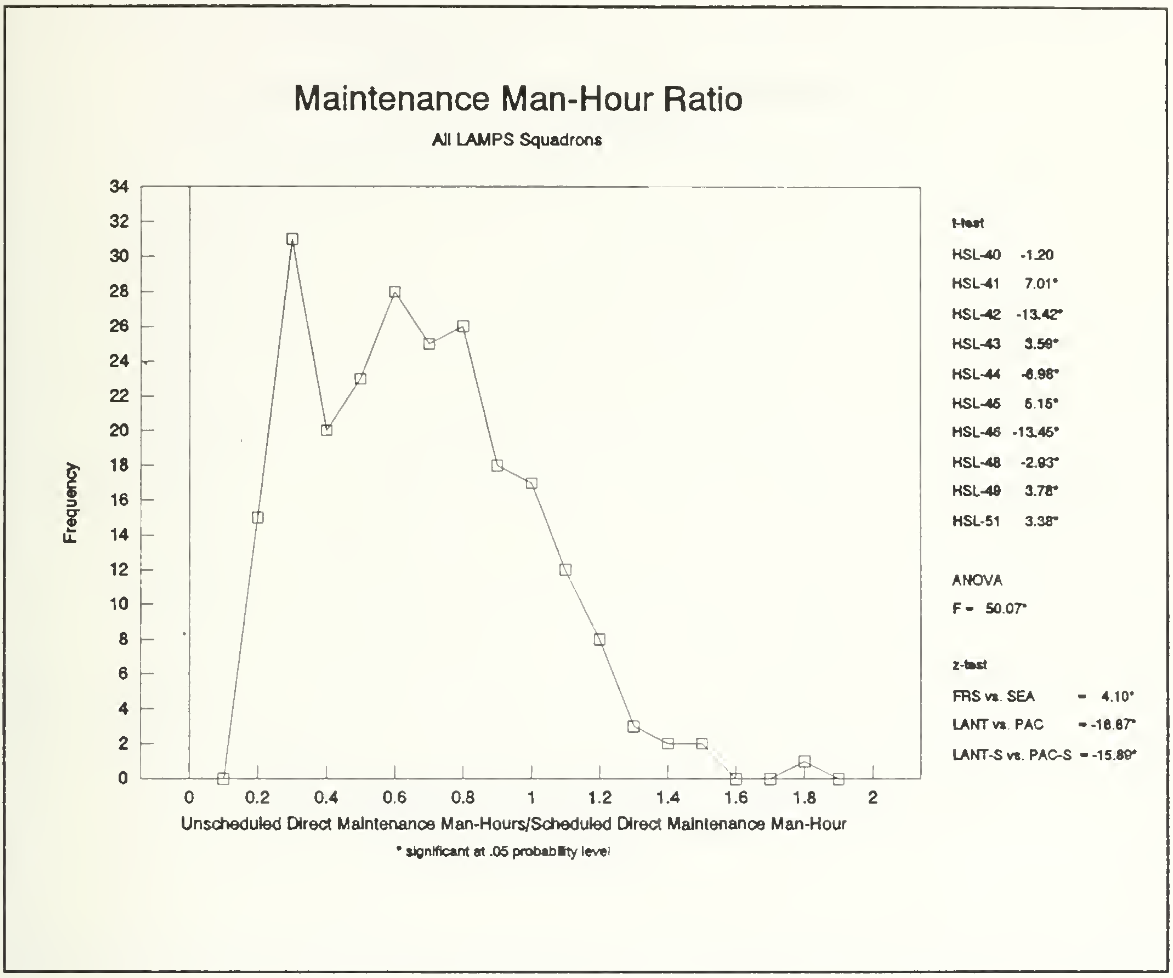

Figure 24

squadrons commit fewer hours to unscheduled maintenance that the Pacific Fleet squadrons.

3. Scheduled Direct Man-Hour (SDMH) Percentage

The frequency distribution is pictured in Figure 25 for all LAMPS squadrons surveyed, and depicts a well defined normal curve with a mean of 64.09 percent. At 74.10, the F-statistic for the Scheduled Direct Man-Hour Ratio is the highest observed for all of the proposed efficiency measures. The t-scores for the individual squadrons are highly

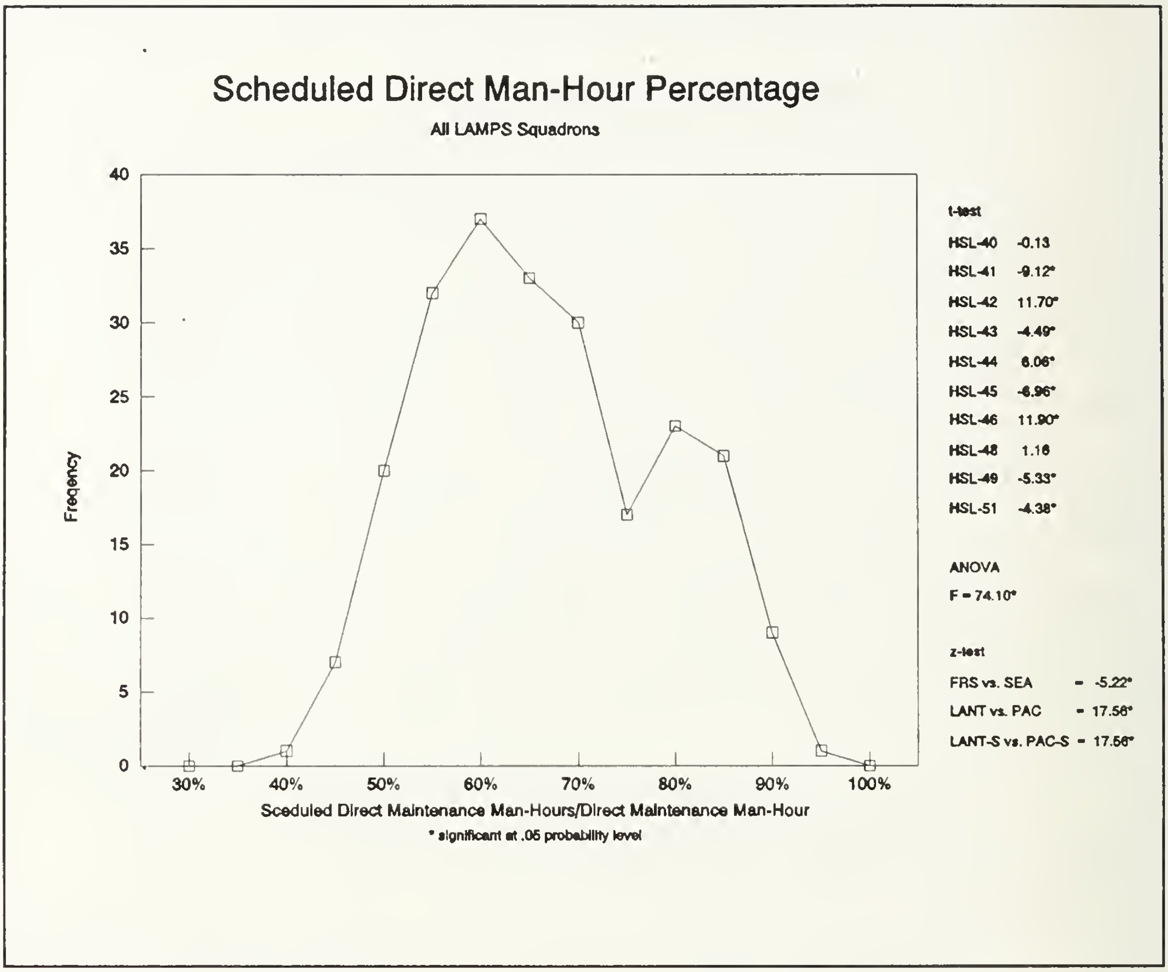

Figure 25

dispersed, ranging from 11.90 to negative 9.12. These statistics show very different distributions indicating that there are significant differences between the percentage of total man-hours devoted to scheduled maintenance among the squadrons. The FRS mean is significantly lower than that of the deploying squadrons. However, the LANT vs. PAC z-score of 17.56 shows that more direct maintenance man-hours were devoted to scheduled maintenance by the East Coast squadrons.

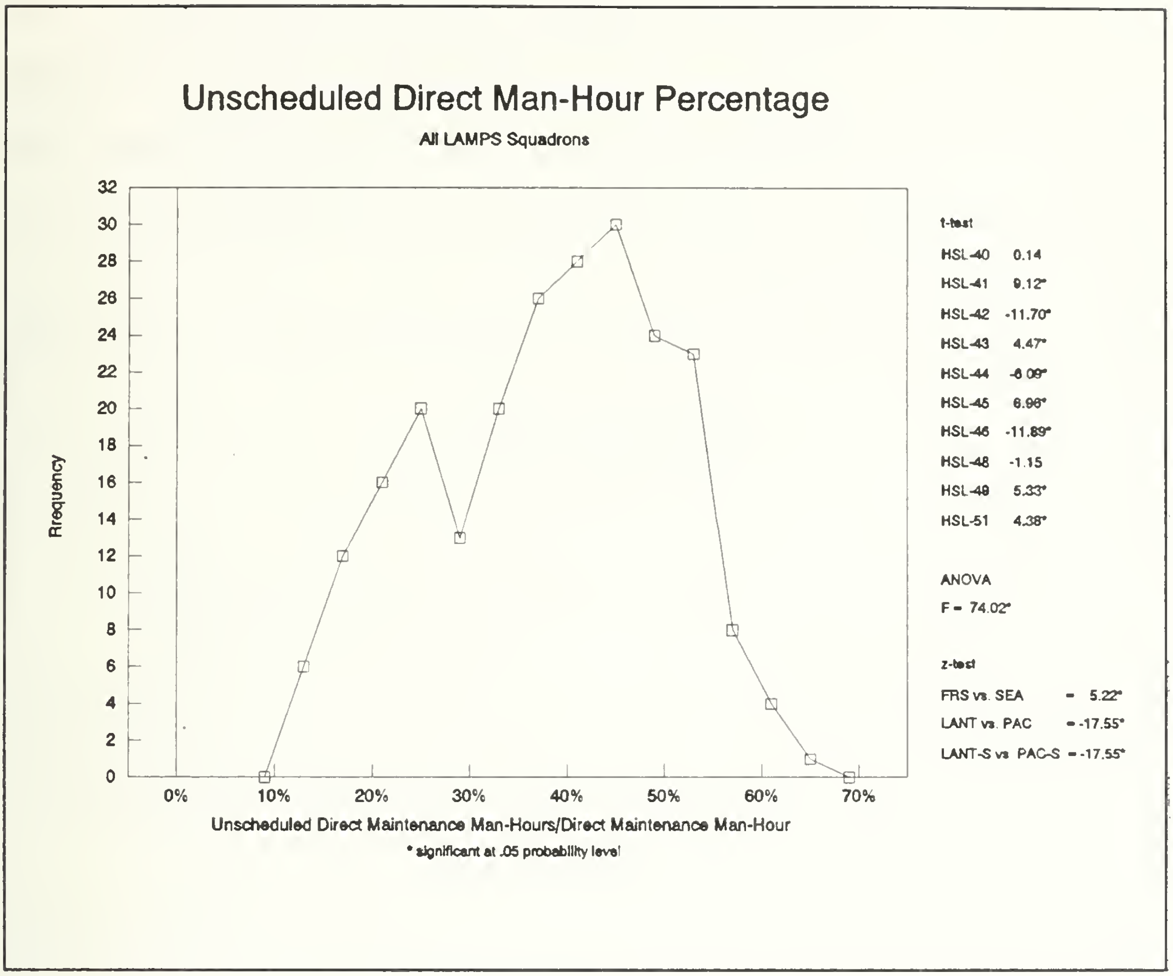

Figure 26

4. Unscheduled Direct Man-Hour (UDMH) Percentage

Figure 26 shows a mirror-image distribution for all LAMPS squadrons. The mean for the curve is 35.91 percent. The PAC-Sea mean of 44.70 percent, compared to a LANT-Sea mean of 24.87 percent, shows that the deploying West Coast squadrons devoted a larger portion of man-hours to unscheduled maintenance than their LANT-Sea counterparts.

The analysis of this measure showed that it was a mirror-image of the Scheduled Direct Man-Hour Ratio. The

statistically significant events are the same whether the Unscheduled or Scheduled Direct Man-Hour Ratio is used. Therefore, it is not recommended that these two measures be used concurrently. However, the causes of these differences should be investigated.

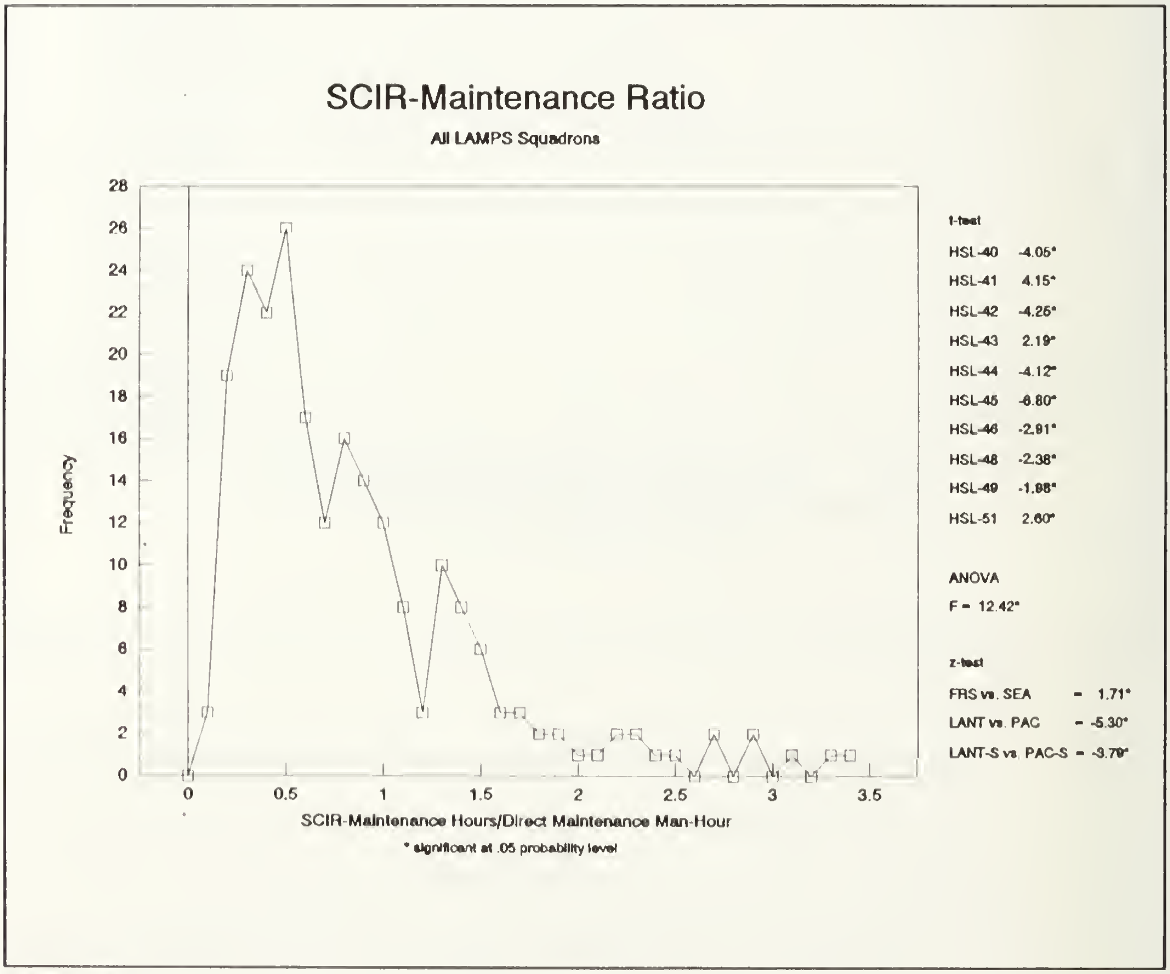

Figure 27

5. SCIR-Maintenance Ratio

The frequency distribution in Figure 27 shows a skewed curve with a mean of 0.94 SCIR-maintenance hours per direct maintenance man-hour.

This is the only measure where all of the t-scores were determined to be outside the 95 percent confidence level. The observed F-statistic of 12.42 also indicated that the means of the individual squadrons were significantly different from each other. In addition, only three of the observed means for the squadrons were greater than 1.0. The z-scores also showed that the participants in the activity tests were different, with the LANT activities lower than the PAC activities.

6. Total Man-Hour Coverage Ratio

Figure 28 depicts the distribution for all LAMPS squadrons. The curve pictures approaches a normal curve with a mean of 7.25 percent.

The Total Man-Hour Coverage Ratio had the lowest F-statistic (3.66) of all of the efficiency measures. The Fleet Replacement Squadrons had a significantly lower mean than the deployable squadrons, 4.44 and 7.98 respectively. The LANT vs. PAC and LANT-Sea vs. PAC-Sea comparisons yielded no significant difference. Both z-scores failed to exceed the five percent probability threshold. When the standard deviations were viewed for each of the data groups, vast dispersion was evident.

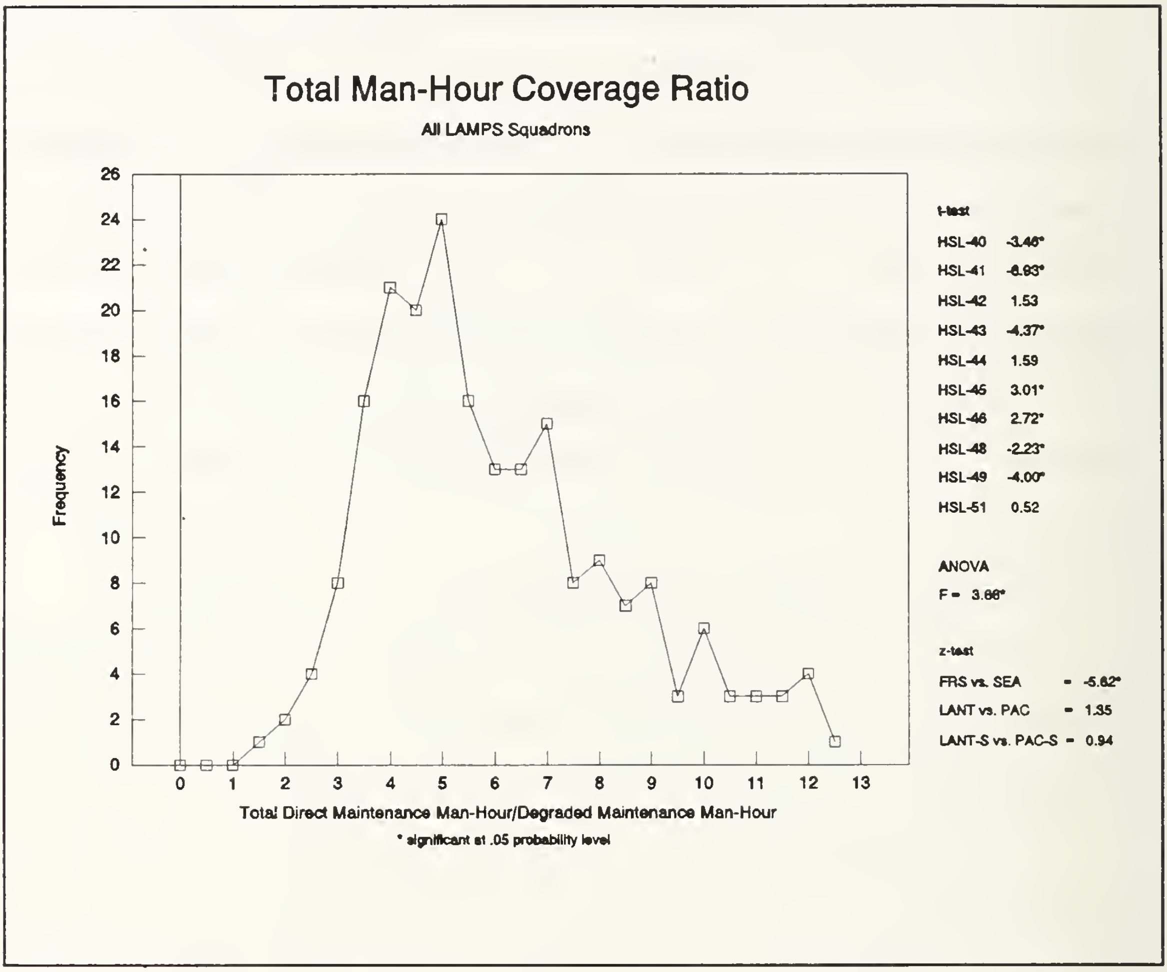

Figure 28

7. Maintenance Man-Hours per Maintenance Action

The frequency curve for all LAMPS squadrons is pictured in Figure 29. The distribution is slightly skewed with a mean of 4.35 maintenance man-hours per maintenance action.

The MMH/MA measure generated an F-statistic of 39.76 which far exceeded the five percent probability threshold of 1.88. This indicated that the means of the squadrons were significantly different. The tests of the specific activities

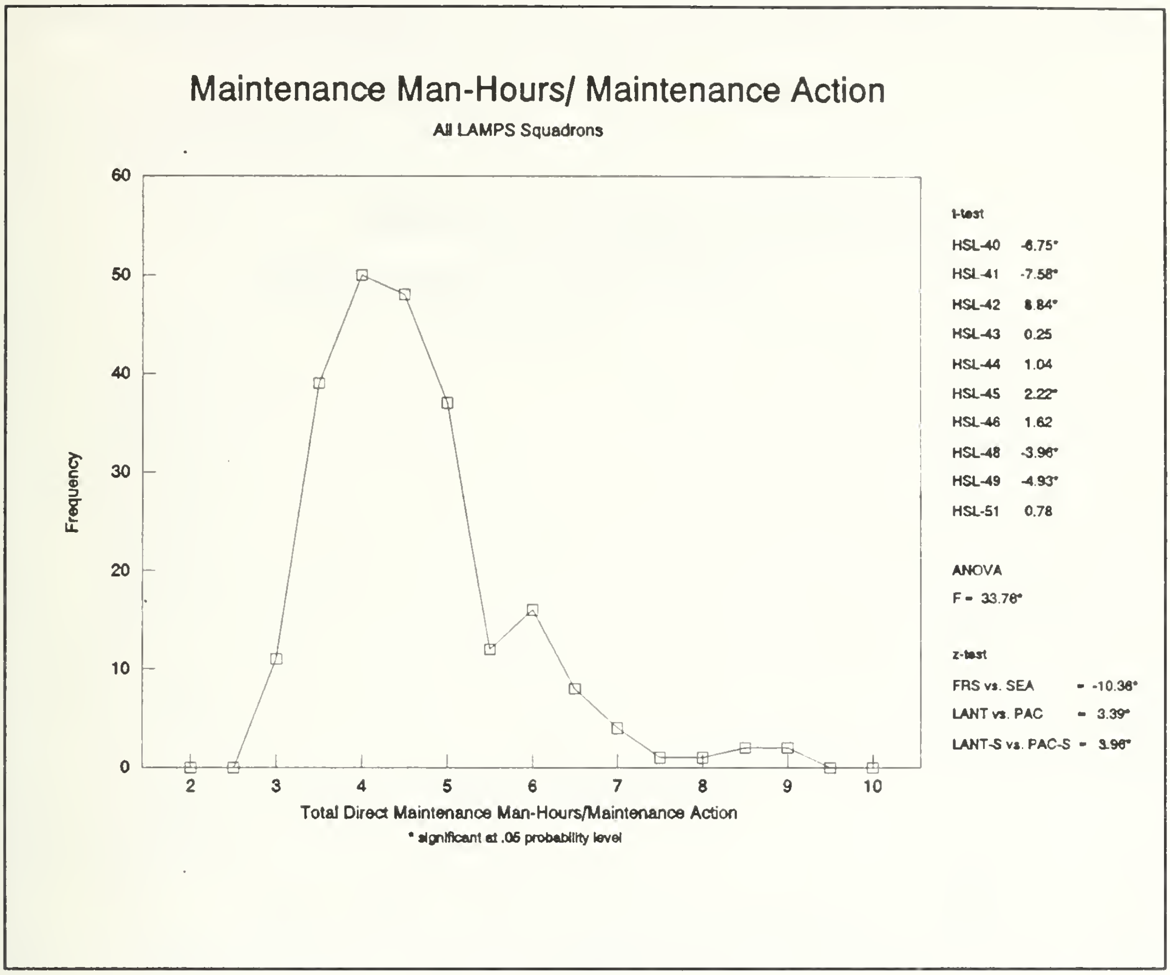

Figure 29

yielded z-scores that exceeded the 95 percent confidence level. The z-score for the FRS vs. SEA test was negative 10.36, which indicated that the FRS has a significantly lower MMH/MA than the deploying squadrons. The observed t-scores for the two FRS squadrons also indicated the lower MMH/MA.

8. Cannibalization Man-Hour Percentage

Figure 30 depicts the frequency distribution of the data points for all LAMPS squadrons. The distribution is

skewed to the right with a mean of 1.88 percent of direct maintenance hours used for cannibalization.

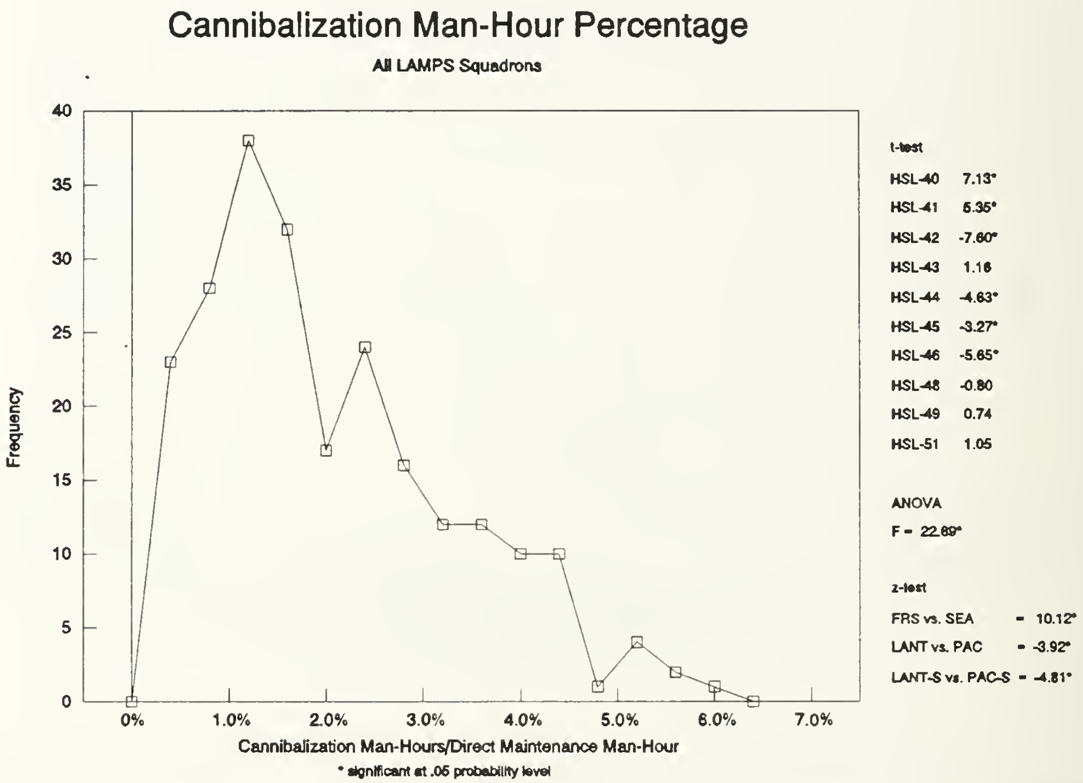

Figure 30

The mean for all of the observations was 1.8776 percent, with a standard deviation of 1.322 percent. This indicates that the distribution was moderately dispersed. With an observed F-statistic of 20.69, the squadron means are significantly different. The FRS vs. SEA activity test yielded a z-score of 10.1181, which indicated that a larger percentage of cannibalization man-hours is recorded by these

activities than in the fleet squadrons. Both LANT vs. PAC tests yielded significant z-scores, with LANT activities lower than PAC activities.

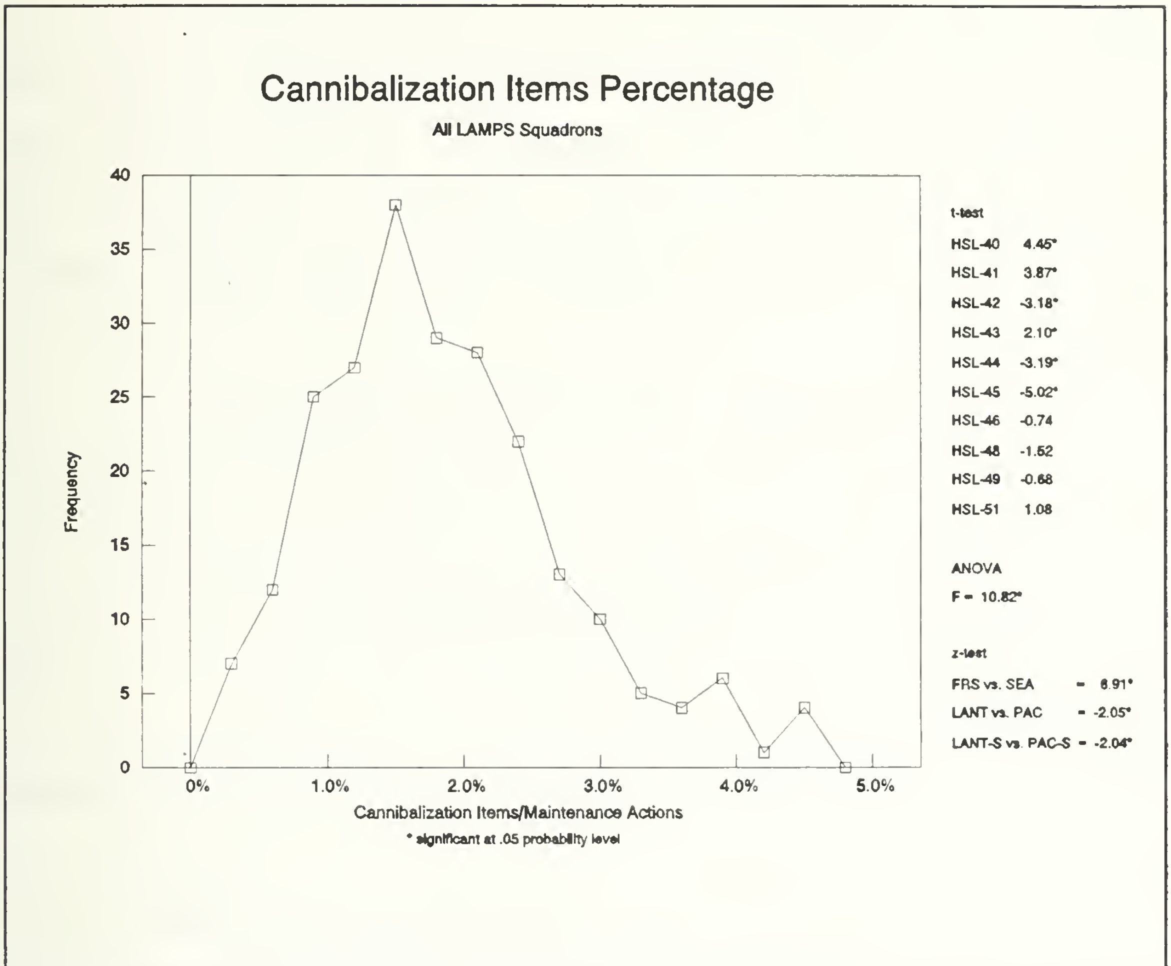

Figure 31

9. Cannibalization Items Percentage

The picture in Figure 31 shows a distribution that approaches the normal curve that is centered around a mean of 1.69 percent of maintenance actions devoted to cannibalization. The mean of the maintenance actions devoted to cannibalization for each of the activates is 2.44 percent

for the FRS, 1.38 percent for LANT-Sea units and 1.62 percent for the PAC-Sea deployable squadrons.

The Cannibalization Items Percentage displayed similar statistical results to the Cannibalization Man-Hour Percentage, with the exception of the tighter, less dispersed standard deviations. The F-statistic of 10.82 signaled that the squadron means were different, and the t-scores had six of ten squadrons fall outside the 95 percent confidence parameter.

10. Cannibalization Items per 100 Flight Hours

The frequency curves for items cannibalized for every 100 flight hours for all LAMPS squadrons is shown in Figure 32. The distribution is skewed to the right with a mean of 5.92 items. The FRS's mean is 11.21 items cannibalized for every 100 flight hours flown. This is significantly greater than the LANT-Sea average of 4.58 items and the PAC-Sea mean of 4.47 items.

The activity tests showed the Fleet Replacement Squadron's with a greater mean of Cannibalization Items per 100 Flight Hours than the deploying squadrons, which concurs with the findings of the two previous measures. However, the LANT activities were not significantly different from the PAC activities with regards to this statistic. In addition, the mean and t-score of one squadron were markedly lower than the rest of the squadrons.

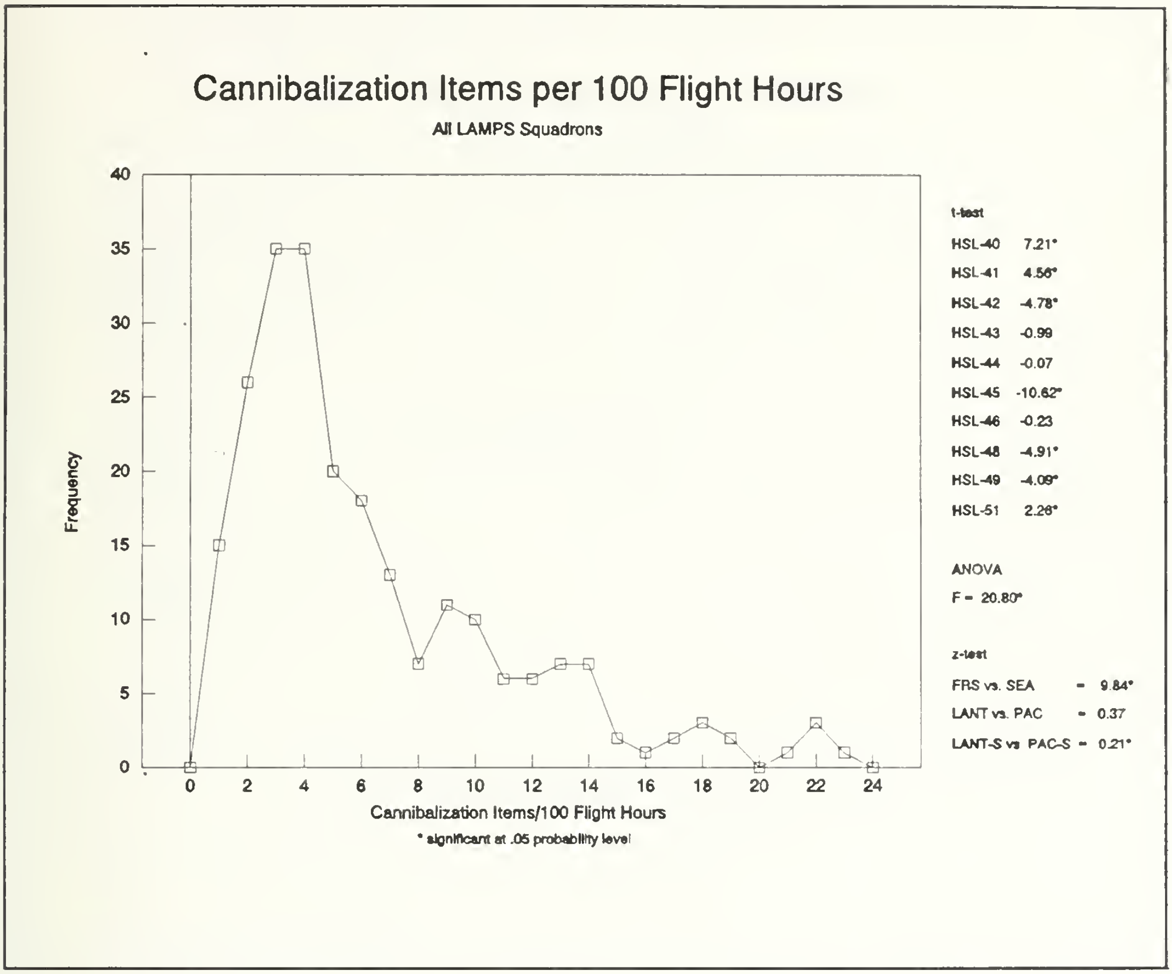

Figure 32

D. QUALITY

1. Mean Time Between Failures (MTBF)

The distribution of historical observations for all LAMPS squadrons surveyed is pictured in Figure 33. The resulting distribution approximates the normal curve with a mean of 0.38 flight hours between maintenance actions.

The MTBF measure yielded an F-statistic of 21.59 which indicated that the unit means were significantly different. The resulting t-scores showed the two Fleet Replacement

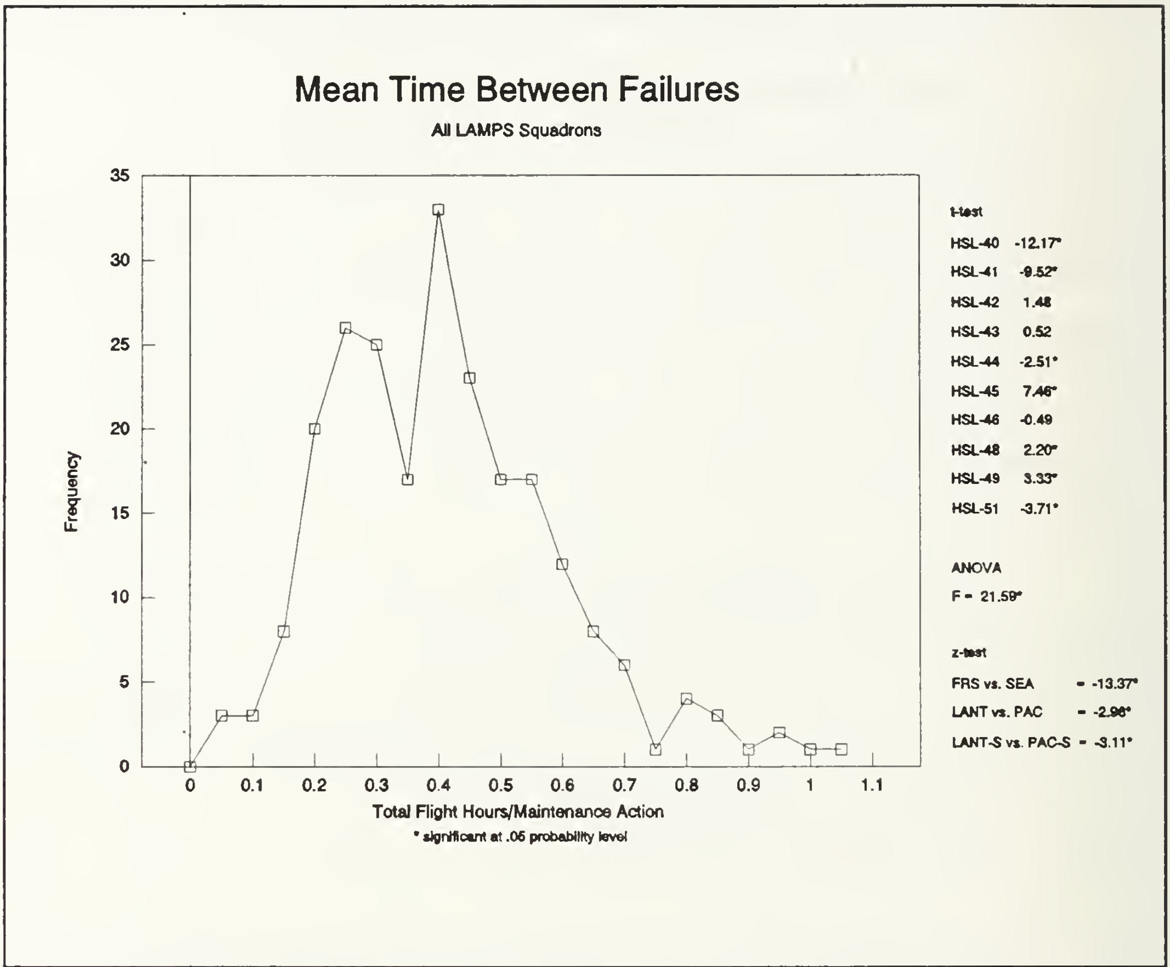

Figure 33

Squadrons with means that were greater than nine points below the mean for all activities. One fleet squadron has a resulting t-score that was seven points greater than the group mean. The activity z-test comparing the FRS with the fleet squadrons, resulted in a score of negative 13.37 showing the FRSs significantly below the SEA group. In addition, the LANT activities were markedly lower that the PAC activities with z-scores of negative 2.96 and negative 3.11 respectively.

2. Corrosion Control Ratio

The bimodal distribution representing all squadrons is pictured in Figure 34. The distribution has a mean of 26.49 percent corrosion control man-hours per direct maintenance hours and a standard deviation of 16.02 percent.

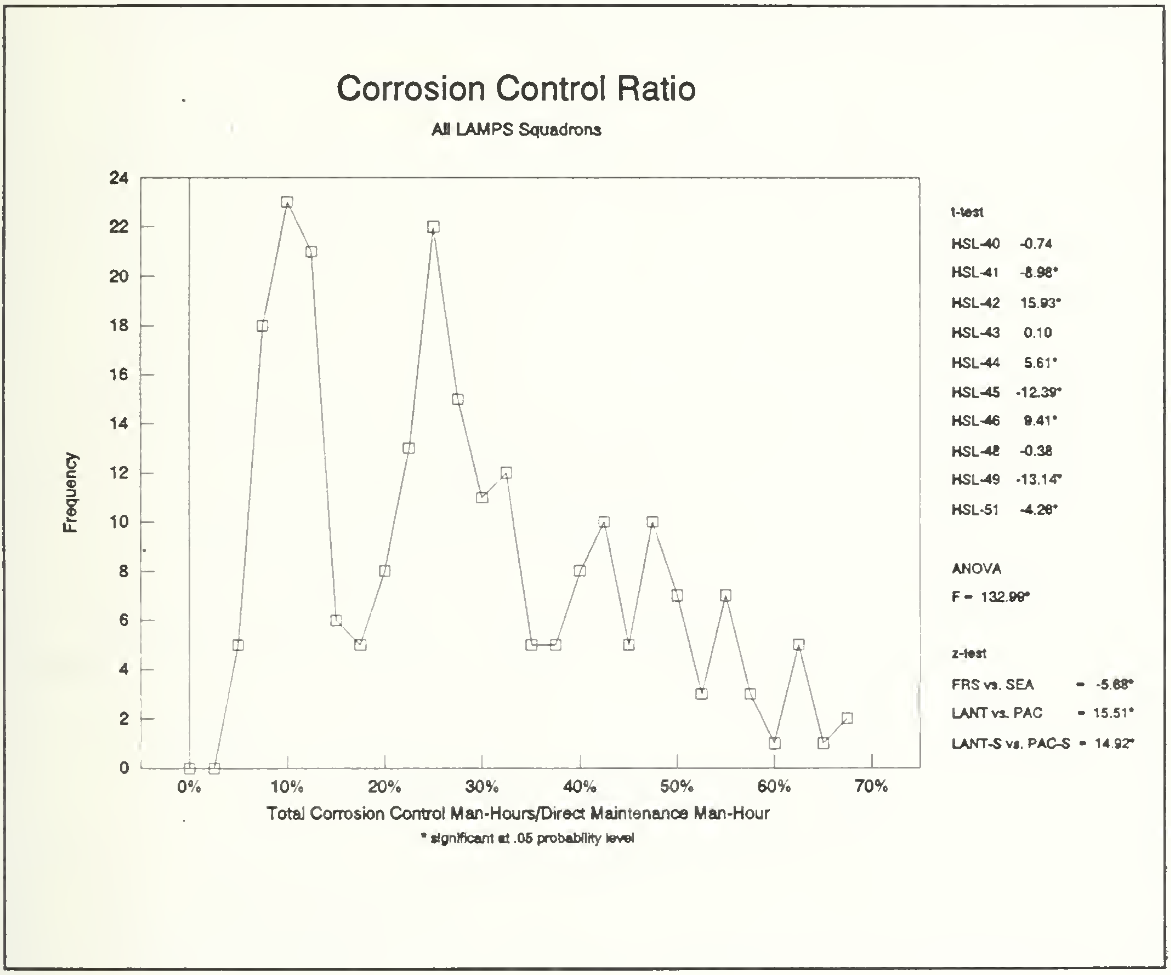

Figure 34

The F-statistic of 132.99 for the Corrosion Control Ratio was the highest observation of all the Quality measures, and the highest observation for all of the measures analyzed. In addition, the range of squadron means extended from a low

of 9.446 percent to a high of 55.53 percent. The LANT vs. PAC and LANT-Sea and PAC-Sea activity tests showed the LANT groups devoting significantly higher percentages of man-hours to corrosion control than their PAC counterparts. The resulting z-scores of 15.51 for the LANT vs. PAC test and 14.92 for the LANT-Sea vs. PAC-Sea test highlighted this difference.

3. Corrosion Control to Flight Hours Ratio

The distribution of all squadrons surveyed in Figure 35 is highly skewed with a mean of 5.06 corrosion control hours per flight hour. The highlight curve pictured in Figure 36 appears to be a uniform distribution. The standard deviation of 9.57 hours supports this conclusion.

The highest observed Corrosion Control to Flight Hour Ratio mean was 15.09 hours, with two squadrons reporting CC/FH Ratio means of less than 1.0. In both LANT vs. PAC activity tests, LANT activities scored significantly higher with a z-score of 5.26 for all Atlantic and Pacific Fleet activates and a score of 4.85 for the deploying units.

4. Unscheduled Man-Hours Ratio

The resulting frequency distribution for the Unscheduled Man-Hour Ratio is shown in Figure 37. The distribution is skewed slightly to the left with a mean of 94.81 percent of all unscheduled man-hours devoted to maintenance other than corrosion.

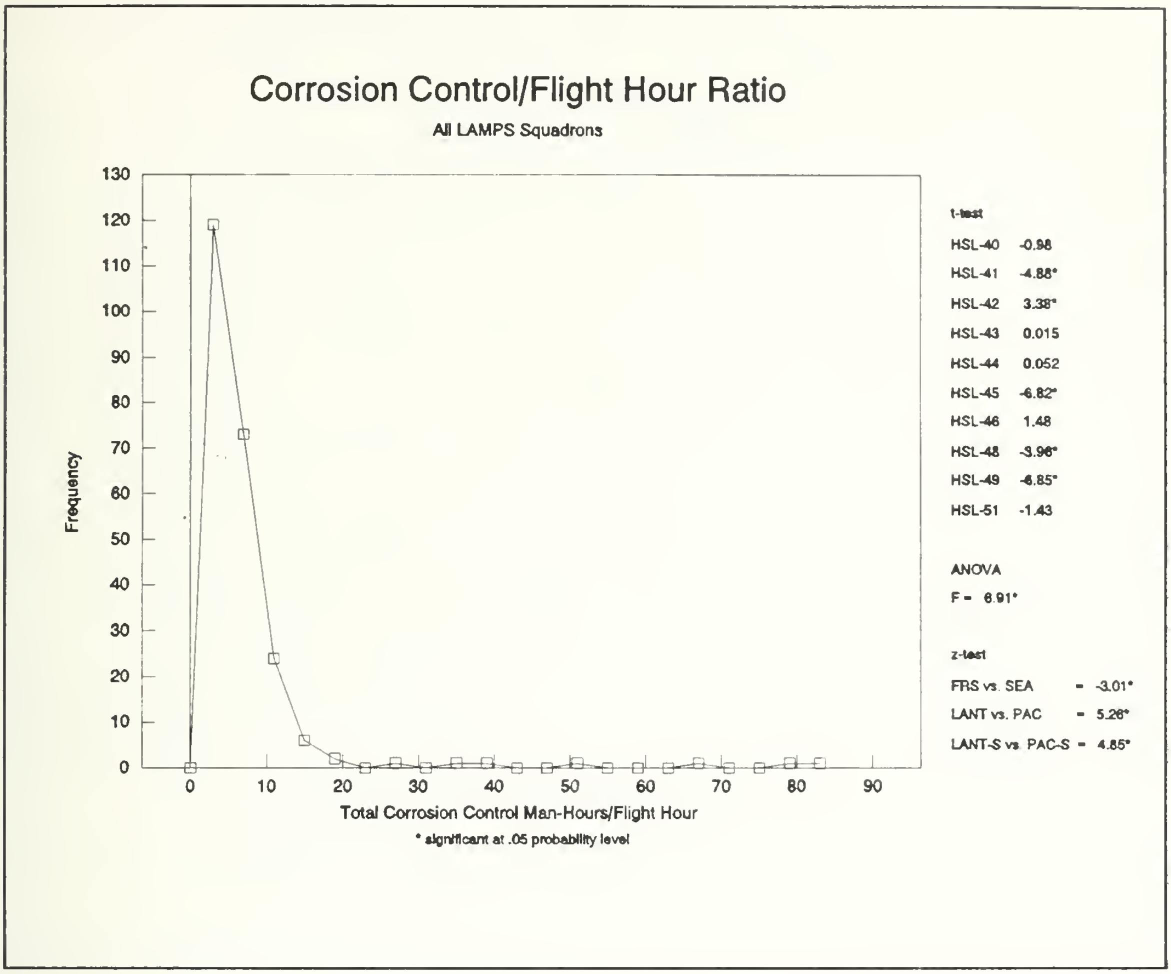

Figure 35

With an F-statistic of 11.55, the means of the squadrons are not similar. The activity test yielded a z-score of negative 7.48 that indicated that the FRS mean was significantly lower than that of the deploying squadrons. The resulting t-scores for the two FRSs were negative 5.48 and negative 3.29 which illustrates the magnitude of the difference between the FRS and the remainder of the squadrons.

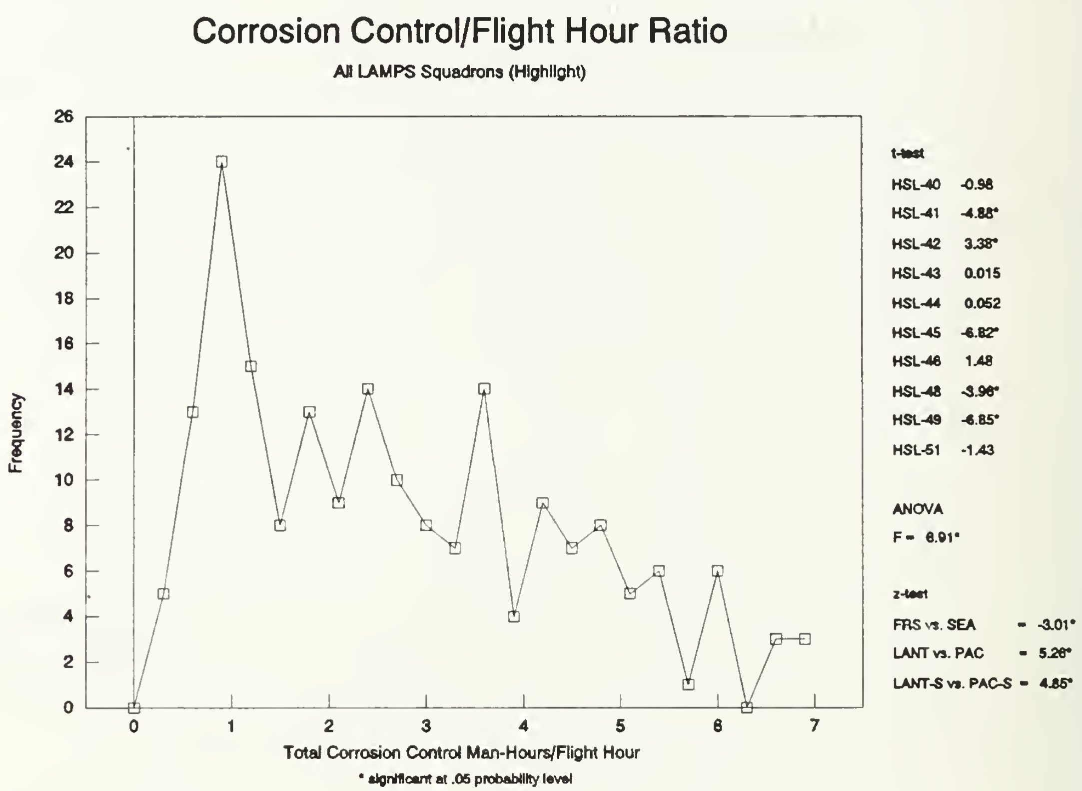

Figure 36

E. PRODUCTIVITY

1. Total Man-Hour/Flight Hour Ratio

Figure 38 displays the results for all LAMPS squadrons and Figure 39 is a highlight of the same group. The highlight frequency distribution in Figure 39 depicts a fairly normal distribution below 30 maintenance man-hours per flight hour. The mean for the frequency curve for all LAMPS activities is 15.90 man-hours with a standard deviation of 19.37 man-hours.

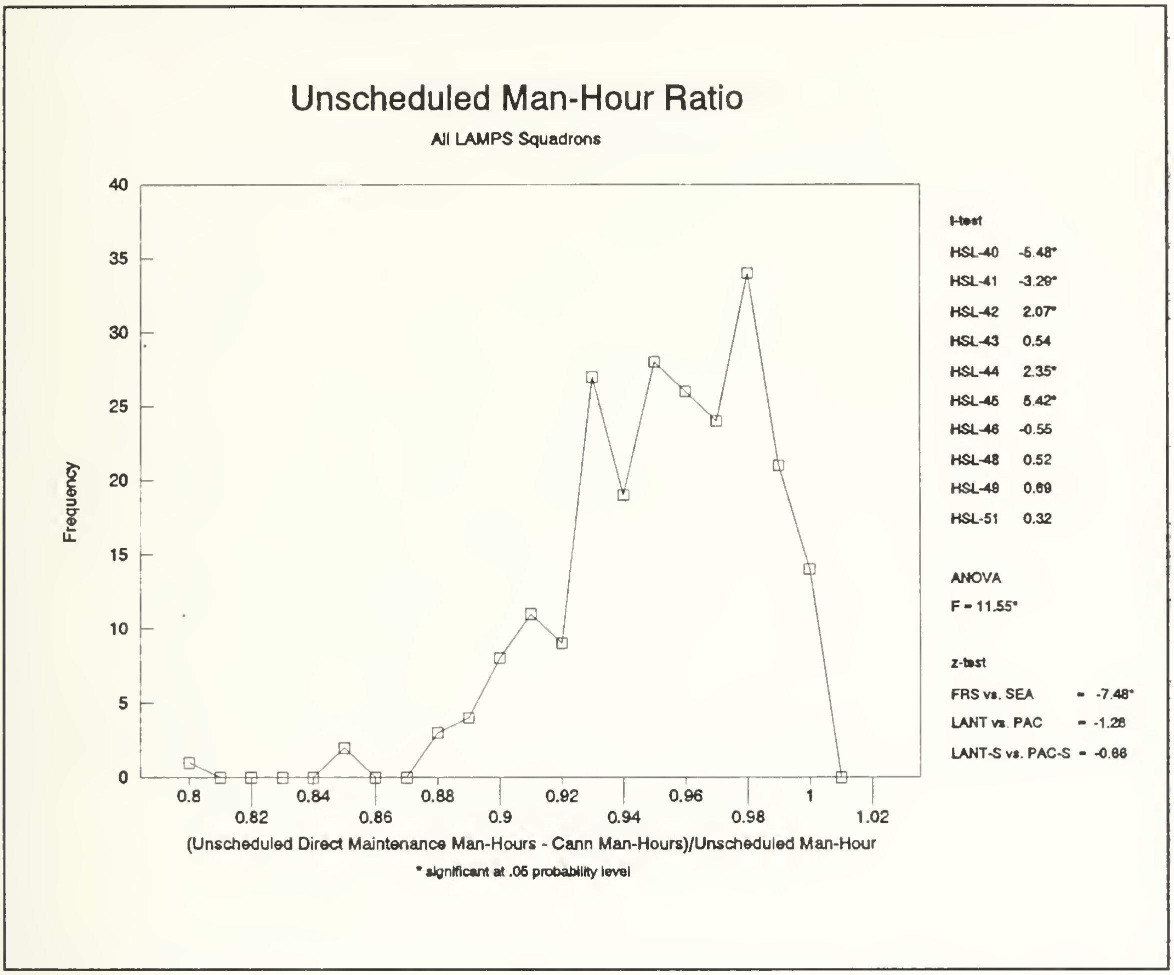

Figure 37

The Total Man-Hour/Flight Hour Ratio resulted in the lowest F-statistic, 4.66, for all of the Productivity measures. The observed mean of one squadron exceeded its next competitor by 12 man-hours. The range of the means of the squadrons ranged from 7.592 to 34.3 man-hours per flight hour. Both of the activity tests showed the Atlantic Fleet squadrons exceeding those of the Pacific Fleet with scores of 3.10 and 2.93.

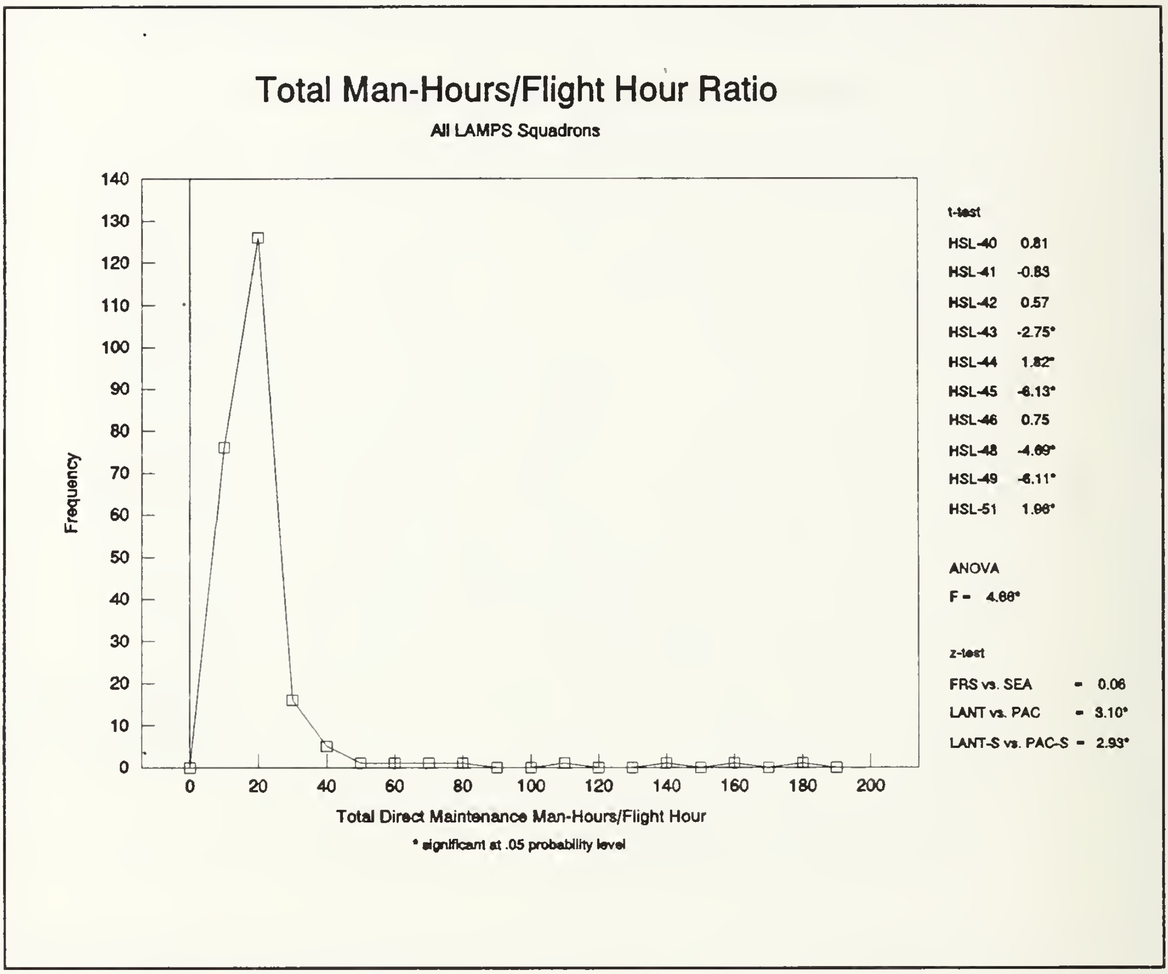

Figure 38

2. Scheduled Man-Hour/Flight Hour Ratio

Figure 40 is a highly skewed frequency distribution with a mean of 10.80 man-hours of scheduled maintenance per flight hour. Figure 41 depicts the frequency distribution for a highlight of all LAMPS squadrons. The resulting distribution appears to more closely resemble a normal distribution.

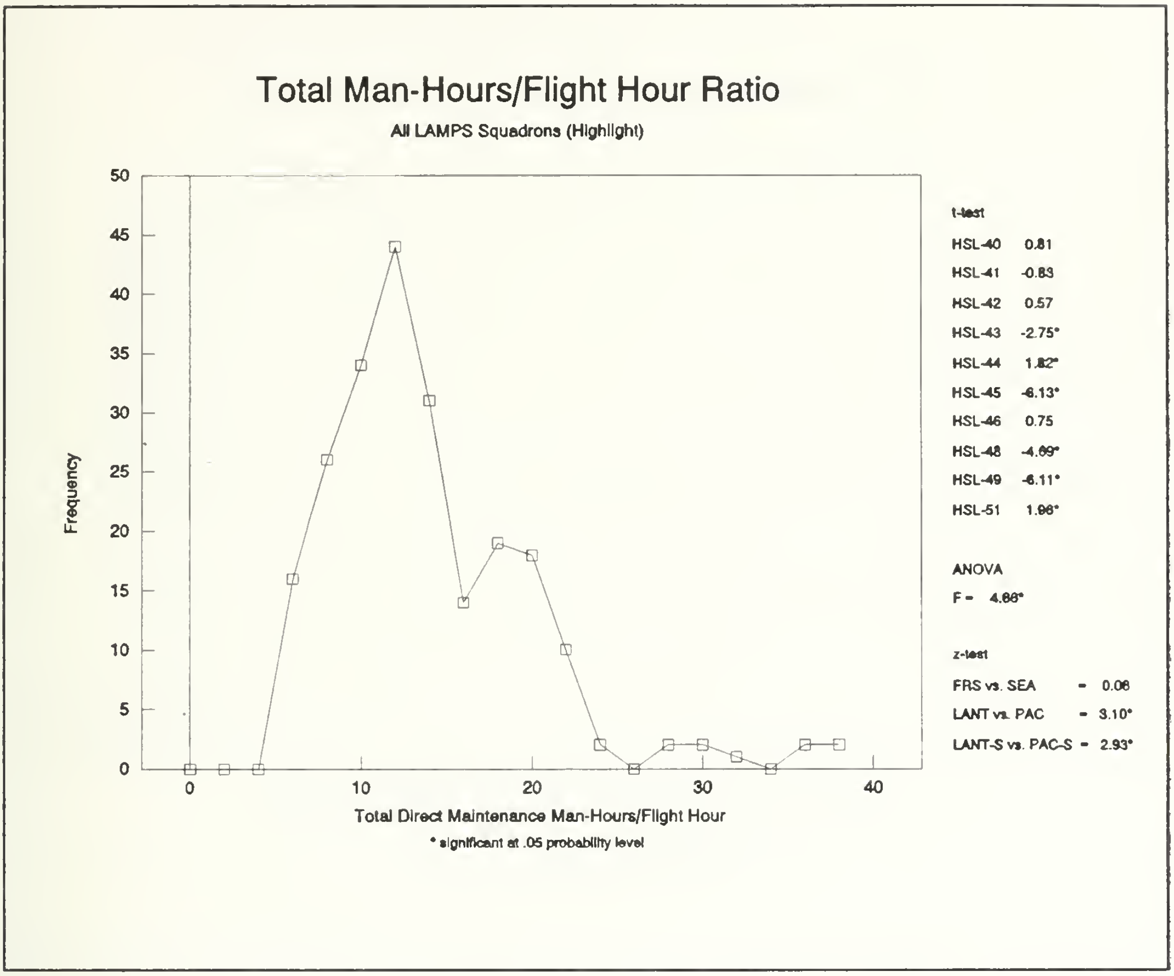

Figure 39

3. Unscheduled Man-Hour/Flight Hour Ratio

The frequency distribution for all LAMPS squadrons is shown in Figure 42 and depicts a highly skewed curve that closely resembles the curves for the preceding two measures. Figure 43 depicts the frequency curve for the associated highlight of all squadrons surveyed. This distribution, with a mean of 5.10 man-hours shows a curve that is dramatically less skewed than the graph in Figure 42.

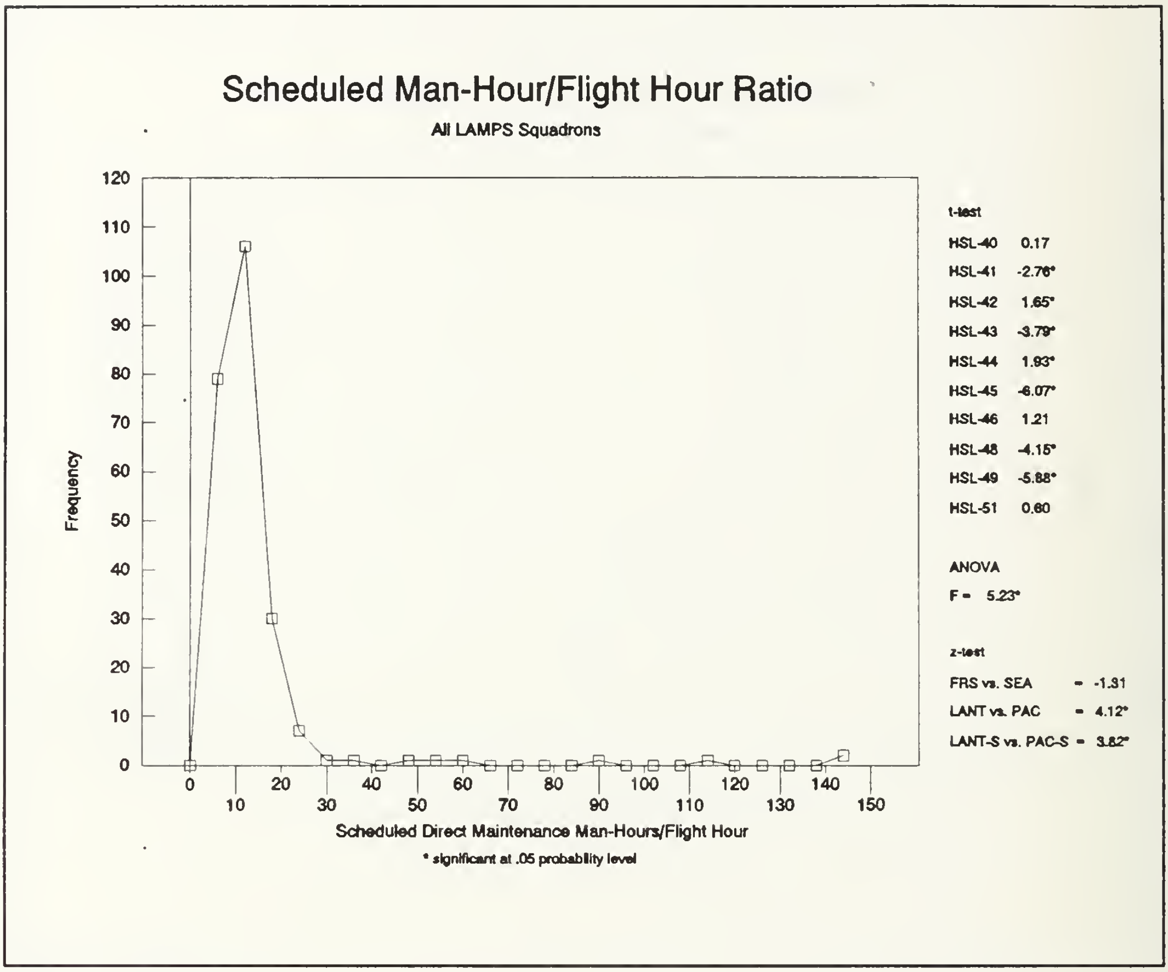

Figure 40

From the ANOVA test, an F-statistic of 7.21 was determined, which indicated that the squadron means are significantly different. The observed means had a range of 3.203 to 9.68. In addition three squadrons had standard deviations greater than 2.5. The z-score for the FRS vs. SEA activities yielded a significant score of 4.54692, which exceeded the five percent probability threshold.

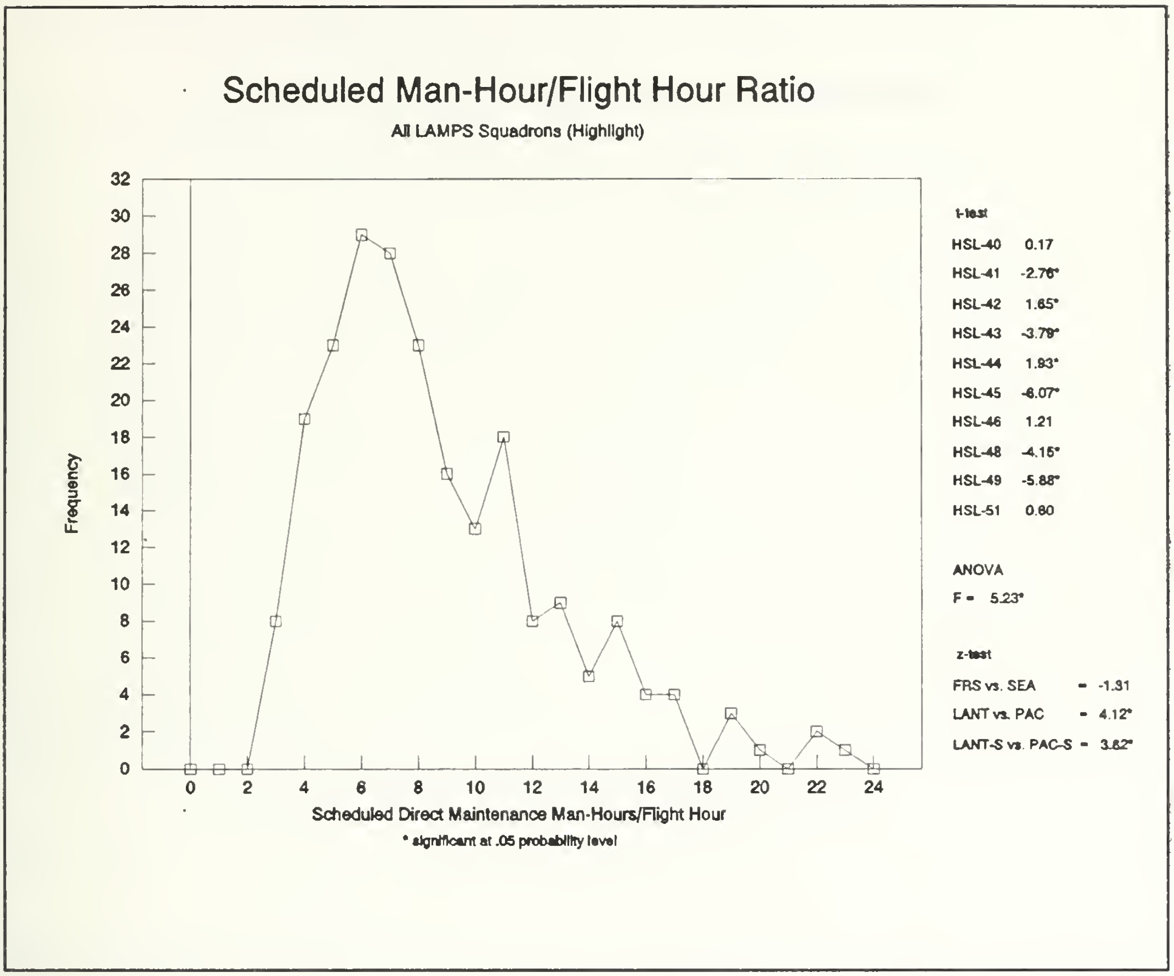

Figure 41

4. Total Flight Hour/Total Man-Hour Ratio

The curve pictured in Figure 44 shows a normal distribution centered around a mean of 0.09 flight hours per direct maintenance man-hour. The observed means are: 0.06 flight hours for the FRS group; 0.08 flight hours for the LANT-Sea units; and 0.11 flight hours for the PAC-Sea deploying squadrons.

Analysis of the Flight Hour/Total Man-Hour Ratio yielded an F-statistic of 23.70, the highest for all of the

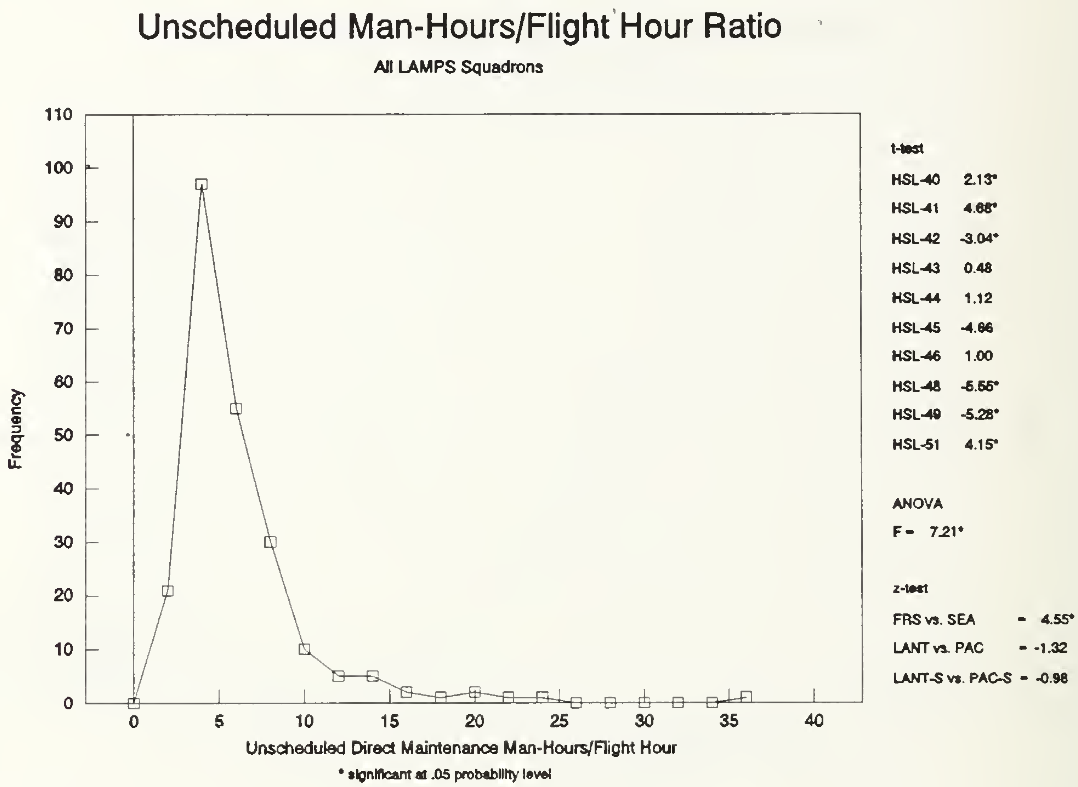

Figure 42

productivity measures. Eight of the squadron t-scores fell outside the 95 percent confidence threshold. In addition, all of the activity tests garnered significant results. With a z-score of negative 7.86, the FRS either logged significantly less flight hours per maintenance man-hour than the deploying squadrons, or significantly more maintenance hours than flight hours. The z-scores of negative 4.42 and negative 4.48 show the LANT and LANT-Sea groups performing comparatively to the FRS activities.

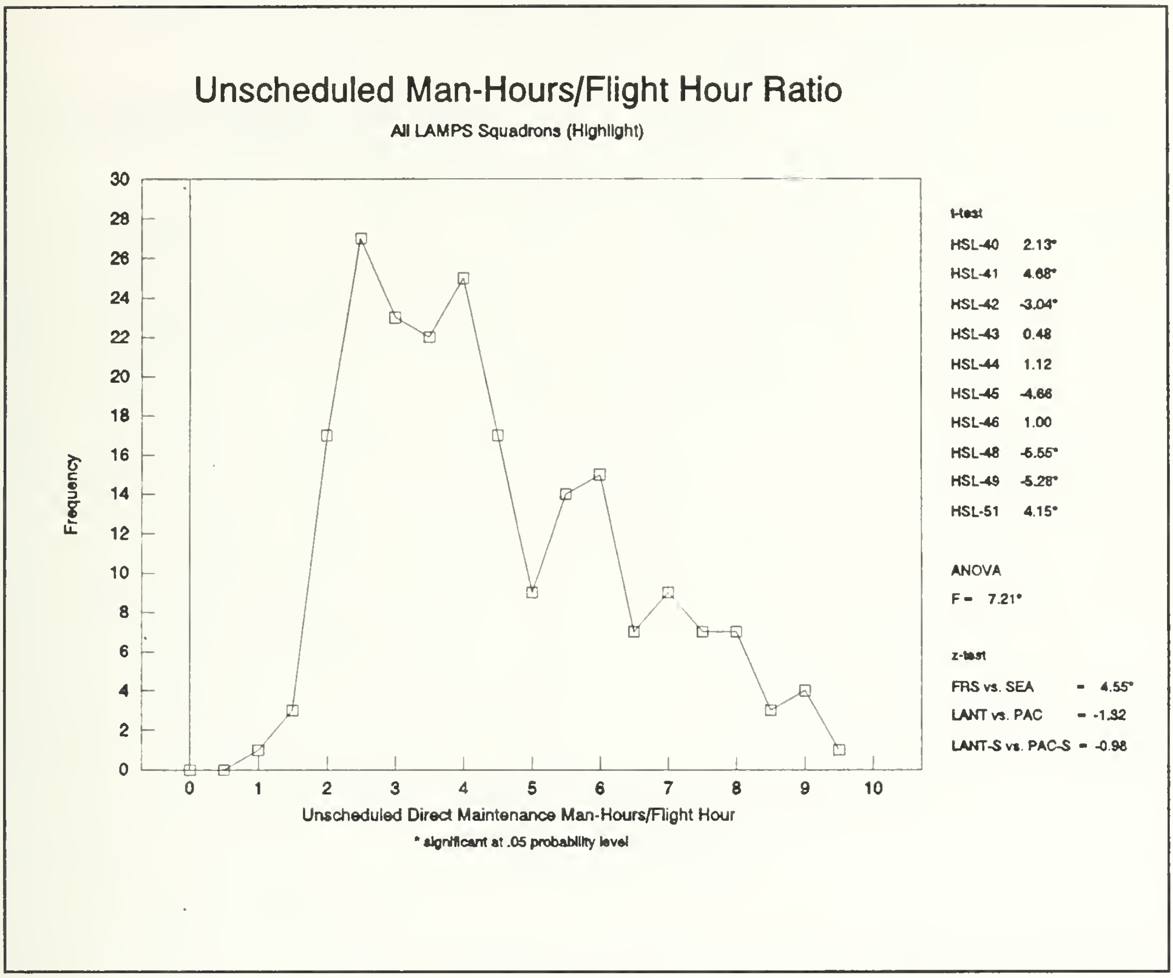

Figure 43

F. SUMMARY

This chapter commenced with a description of the sources for the data used in the analysis of the alternative performance measures. The statistical methods and processes used to analyze the performance measures were detailed. Within the umbrella of each performance improvement element, several measures were described, discussed and analyzed. In addition, frequency distributions were compiled and graphed for all LAMPS squadrons, and three specific activity groups.

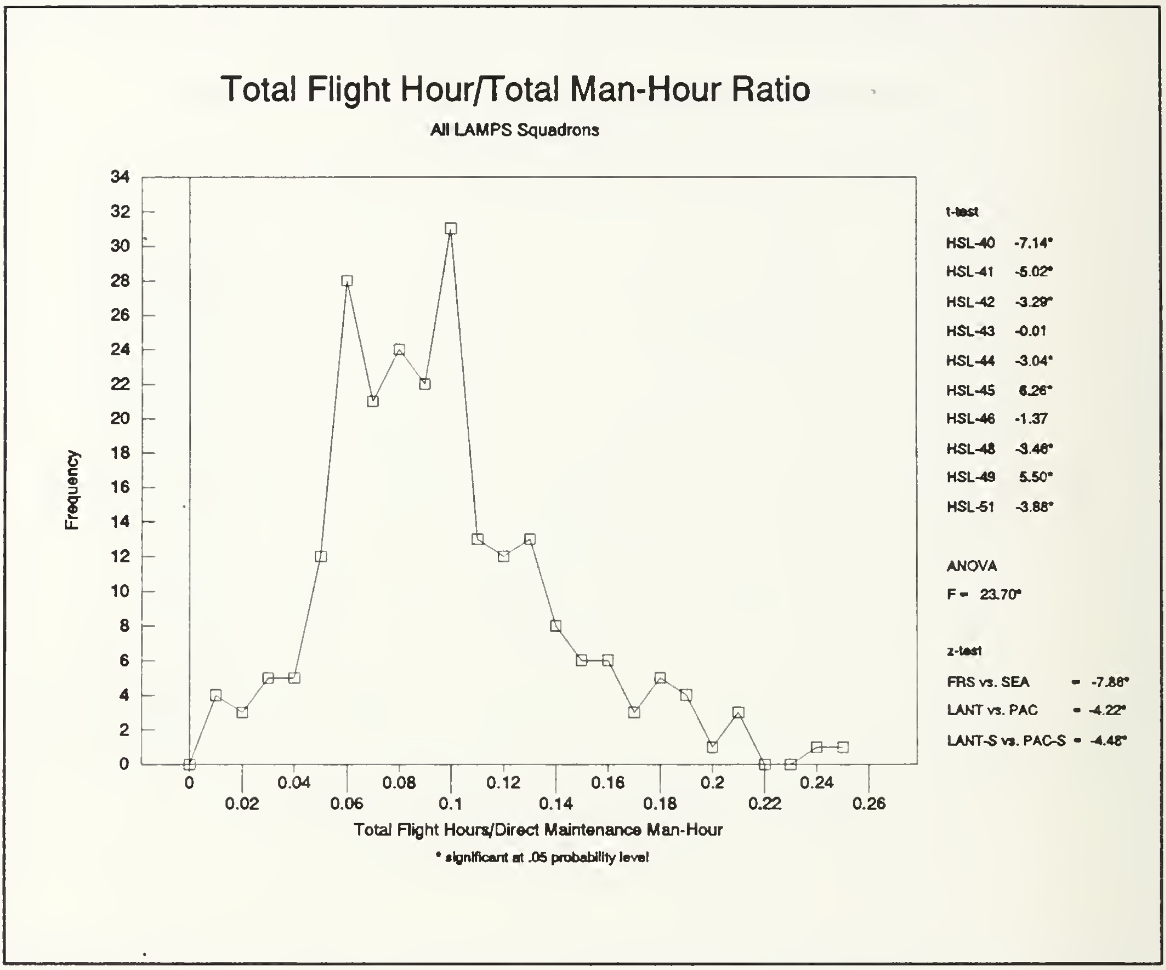

Figure 44

See Figure 45 for a summary of the results of the statistical tests by activity.

Performance Measure	FRS vs. SEA	LANT vs. PAC	LANT-Sea vs. PAC-Sea	ANOVA
Yes indicates statistical significance at a 5% probability level.				
EFFECTIVENESS MEASURES				
Mission Capability	No	Yes	No	Yes
Optimum Capability	Yes	Yes	Yes	Yes
Mission Capability/Optimum Capability	No	No	No	Yes
Sortie Execution	Yes	No	No	Yes
Utilization Rate	Yes	Yes	Yes	Yes
EFFICIENCY MEASURES				
Labor Usage Rate	Yes	Yes	Yes	Yes
Maintenance Man-Hour Ratio	Yes	Yes	Yes	Yes
Scheduled Direct Man-Hour Ratio	Yes	Yes	Yes	Yes
Unscheduled Direct Man-Hour Ratio	Yes	Yes	Yes	Yes
SCIR-Maintenance Ratio	Yes	Yes	Yes	Yes
Total Man-Hour Coverage Ratio	Yes	No	No	Yes
Maintenance Man-Hours per Maintenance Action	Yes	Yes	Yes	Yes
Cannibalization Man-Hour Percentage	Yes	Yes	Yes	Yes
Cannibalization Items Percentage	Yes	Yes	Yes	Yes
Cannibalization Items per 100 Flight Hours	Yes	No	No	Yes
QUALITY MEASURES				
Mean Time Between Failures	Yes	Yes	Yes	Yes
Corrosion Control Ratio	Yes	Yes	Yes	Yes
Corrosion Control/Flight Hour Ratio	Yes	Yes	Yes	Yes
Unscheduled Man-Hour Ratio	Yes	No	No	Yes
PRODUCTIVITY MEASURES				
Total Direct Man-Hour/Flight Hour Ratio	No	Yes	Yes	Yes
Scheduled Direct Man-Hour/Flight Hour Ratio	No	Yes	Yes	Yes
Unscheduled Direct Man-Hour/Flight Hour Ratio	Yes	No	No	Yes
Total Flight Hour/Total Man-Hour Ratio	Yes	Yes	Yes	Yes
Total (of 23)	**19**	**17**	**16**	**23**

Figure 45 Summary of Significant Differences for the Activity Tests

VI. DISCUSSION OF THE MCP/PMT AND OBJECTIVES MATRIX

The concept of performance measures has been explained and many alternative performance metrics have been discussed and analyzed within the context of this thesis. In addition, a new performance measurement model has been suggested. The discussion that follows explains how using the Multi-Criteria Productivity/Performance Measurement Model (MCP/PMT) and Objectives Matrix will provide the squadron maintenance officer with a more effective tool with which to control and lead the maintenance department. To highlight the use of the MCP/PMT model, a set of measures will be selected and used in comparison with the Mission Capability rate of all of the squadrons surveyed.

A. THE NEED FOR A NEW SYSTEM OF PERFORMANCE MEASUREMENT

From the analysis in Chapter V, the differences in the statistics highlight the dispersion in the metrics used to analyze aviation maintenance. The need to better allocate the limited resources available and meet the mission requirements is a strong impetus to re-evaluate current maintenance measurement practices. There are several reasons for a squadron to evaluate the manner in which maintenance is measured and managed.

The primary reason for further examination of the current maintenance measurement system is the degree to which the statistics measured and analyzed in Chapter V are diverse and varied, given that each squadron has relatively the same resources and commitments. This is evidence of the magnitude of the effect of the management practices on the performance of a maintenance department. The analysis focuses on the rather inescapable conclusion that there exists a tremendous potential for improvement in the measurement of aviation maintenance area.

The second reason is the fact that for the two years of observed data, only one squadron mean exceeded the CNO's goal of 77 percent Mission Capability. While managing to goals and targets is not in congruence with the total quality philosophy of Dr. W. Edwards Deming and the U.S. Navy, the fact remains that, if current maintenance goals are truly indicative of operational needs, efforts need to be made to improve the Mission Capability percentage of the squadrons. An improved view of the factors affecting the performance of the maintenance department might serve to increase this output measure.

Third, as a measure of overall performance, the material condition reporting status of an aircraft or squadron is limited in its scope. Measures of FMC/PMC/NMC fail to address all of the elements that formulate a true performance measure, as noted in Chapter III.

Fourth, the need to re-evaluate the way maintenance performance is measured is based on the fact that performance measures, in themselves, do not improve productivity. [Ref. 13: p. 15] Just by measuring, either with the existing measures (Mission Capability, Full Mission Capability, etc.) or the metrics proposed in Chapter III, improvement of maintenance performance of the squadrons will not be realized. To achieve value enhancing improvement, every aspect of the maintenance system requires examination. The MCP/PMT should provide an excellent starting point. Interviews conducted with squadron Maintenance Officers revealed that effectiveness is the only performance element that is measured by the LAMPS MK III community. Their perception was that if all commitments were met and all flights were flown, then the maintenance department must be optimizing all of the performance improvement elements (efficiency, effectiveness, quality, productivity, quality of work life, budgetability, and innovation). There were very few specific measures that reflected the other performance elements. In addition, very few Maintenance Officers had a clear definition of each of the seven elements, this meant that the definitions provided by the NAMP and Sink were used to develop and classify alternative performance measures.

The final reason for scrutinizing the existing maintenance system with an eye towards the seven performance improvement elements is to remain in compliance with OPNAVINST 4790.2E.

The NAMP requires all aviation maintenance activities to pursue all efforts to achieve performance improvement.

B. USING THE MCP/PMT MODEL

The Multi-Criteria Productivity/Performance Measurement Technique (MCP/PMT) and the Objectives Matrix[8] are the tools that will be employed to tie together the performance measures discussed in Chapter IV and analyzed in Chapter V.

1. Target System/Unit of Analysis and Identification of Major Performance Elements

The first step in using the MCP/PMT is to determine the major performance elements of the organization. In the case of the aviation maintenance squadron, the performance elements of interest are the seven performance improvement elements (effectiveness, efficiency, quality, productivity, quality of work life, budgetability, innovations) discussed in Chapter III.

Experts suggest that any discussion and development of performance measures for an organization should include all of the participants whose performance is to be measured. This enables the measure to have support from the participants and

[8] The MCP/PMT and the Objective Matrix are discussed in "Planning and Measurement in Your Organization of the Future," by D. Scott Sink and Thomas C. Tuttle. [Ref. 1: pp. 276-285] The majority of the discussion addressing the procedures for using the MCP/PMT and Objective Matrix are from that reference.

should provide a statistic that reflects factors that are controllable by, and understandable to, the organization.

2. Develop Measures for each Performance Element

Select specific measures that best reflect each performance dimension. If one performance element is deemed to be of significantly greater importance than the rest, more than one measure may be used to evaluated that dimension. When selecting a performance measure, each squadron should consider the factors concerning measurement criteria mentioned in Chapter III and summarized in Figure 46. This ensures the

1. Consistent and congruent with group and organizational mission goals and objectives.
2. Within the control of the group itself.
3. Comprehensive and, as much as possible, mutually exclusive.
4. Explicit and as objective as possible.
5. Challenging, not to easy, not too difficult.
6. Measurable. There should be reasonable visibility of the cause-and-effect relationships between group activities and each performance criterion variability.

Figure 46 Factors in Developing Performance Measures

best measure is chosen; one that will work toward achieving the performance improvement goals of the command.

In illustrating the MCP/PMT model, alternative measures were chosen for each of the performance improvement elements. The was no intention to suggest that the measures selected are the best metrics for measuring performance for each of the performance elements. The measures were chosen to highlight the high degree of dispersion between the squadrons.

Performance Dimension	Performance Measure
Effectiveness	Utilization Rate
Efficiency	Maintenance Man-Hour Ratio
Productivity	Total Direct Man-Hour/Flight Hour Ratio
Quality	Mean Time Between Failures
Budgetability	None
Quality of Work Life	None
Innovation	None

Figure 47 Performance Measures Selected For Use in the MCP/PMT Model.

(See Figure 47) As noted in Chapter III, alternative performance measures were not considered for the Quality of Work Life, and Innovation elements. Because data was unavailable, Budgetability was not measured.

3. Develop a Performance Scale for each Performance Measure and Element

Here a rating system is established for different levels of performance. An acceptable level of performance for the measure receives the median score of 50. An outstanding level of performance is awarded a score of 100. An unsatisfactory performance level is given a score of 0. Within these three points, other levels of performance can be given appropriate scores. The result should be a scale of performance levels with corresponding scores from 0 to 100.

In developing the model for this thesis, the mean value for each performance measure from the entire sample of

all LAMPS squadrons was given the middle score of 50. The other levels were determined from analyzing the maximum and minimum observed values and the standard deviation of the sample.

4. Develop Ranking, Rating, and Weighting for the Elements and Measures

Each performance improvement element should be ranked in order of importance on a scale of one to seven, with the highest priority element being ranked first, the second highest priority element being ranked second, etc. Once ranked, each element should be given a weight in relation to its importance. The highest ranked element should be given the weight of 100. The element ranked second should be given a weight that is of equal or lesser value than that given to the first ranked element. This procedure should be followed for the remaining elements, ensuring that the ranks and the weights correspond.

The final operation is developing a percentage factor for each element. The percentage factor is determined by dividing each factor's weight by the sum of all the weights. The percentage factor depicts the relative proportionality of each performance improvement element and associated measure. One implication inherent in the weight is that it gives the squadron maintenance officer a benchmark as to how much time to devote to each element.

Performance Criteria	Rank	Weight	Adjusted Weight	Subjective Weighting	Resulting Rank
Effectiveness	2	89	94	0.158	2
Efficiency	3	79	84	0.168	5
Quality	1	95	100	0.168	4
Productivity	5	82	87	0.146	4
Budgetability	7	89	63	0.106	7
Quality of Work Life	4	84	89	0.150	3
Innovation	6	73	78	0.131	6
Total		560	595	1.001	

Figure 48 Results of Rankings of Performance Improvement Criteria

During the interviews with the squadron and wing Maintenance Officers, the nine respondents were asked to rank and weight the seven performance improvement elements. These inputs were tallied and the result is shown in Figure 48. These weights were used to compute the subjective weightings for the Objectives Matrix. The budgetability element was ranked lowest by all of the West Coast MOs. This was probably due to the fact that West Coast squadrons do not receive an AFM budget.

Because data for measures addressing three of the performance improvement elements, data for those measures were not analyzed. Any attempt to develop a score for the three elements that were omitted would have a mitigating effect on the model. The remaining four performance improvement

Performance Criteria	Rank	Adjusted Weight	Subjective Weighting
Effectiveness	2	94	0.258
Efficiency	4	84	0.230
Quality	1	100	0.274
Productivity	3	87	0.238
Total		365	1.000

Figure 49 Adjusted Rankings and Weightings

elements were re-weighted based on the sum of the adjusted weight for those four elements. The results are included in Figure 49.

5. Use the Matrix

In using the MCP/PMT model and Objectives matrix, data on each performance measure is usually gathered and reported on a monthly basis. Each observed measure is compared to the matrix and the score is determined. The score is multiplied by the percentage factor. The sum of the raw scores for each performance improvement element yields the final performance score. This score can be tracked over time to determine if the performance of the activity has improved. In addition, the results of any performance improvement initiatives can be measured by the change in the performance score. Figure 50 displays the completed matrix used in this thesis.

The squadron should revisit this model as necessary. Consideration should be given to changing the levels of performance scores as the squadron improves. In addition,

Performance Elements

	Effectiveness	Efficiency	Quality	Productivity	Budgetability	QOWL	Innovation	Score
Performance Measure	Util. Rate	MMH Ratio	MTBF	TDMH	None	None	None	
Actual Performance								
Performance Matrix	15%	0.1	1.1	10				100
	14%	0.2	1.0	11				90
	13%	0.3	0.9	12				80
	12%	0.4	0.8	13				70
	11%	0.5	0.7	14				60
	10%	0.6	0.6	15				50
	9%	0.7	0.5	16				40
	8%	0.8	0.4	17				30
	7%	0.9	0.3	18				20
	6%	1.1	0.2	19				10
	5%	1.2	0.1	20				0
Performance Score					N/A	N/A	N/A	
Subjective Weighting	0.258	0.230	0.274	0.238				1.000
Weighted Score								

Total Performance Score = ______

Figure 50 The Objectives Matrix

performance measures should be scrapped if they cease to provide useful information.

C. PROS AND CONS OF THE MCP/PMT MODEL AND OBJECTIVES MATRIX

The largest benefit of the MCP/PMT model and Objectives Matrix is the increased visibility of the entire maintenance picture. The model provides the squadron maintenance officer with a method to divide and analyze the activity of the squadron's maintenance department within the umbrella of the seven performance improvement elements required by the NAMP. It assists the MO in selecting the most appropriate activities and their associated performance measures to monitor his department. In addition, it provides an avenue for feedback on the progress of the performance improvement initiatives implemented by the squadron.

While the model is relatively simple to use, there are some obvious criticisms that warrant mention. The first is that the model treats each element as mutually exclusive. [Ref. 1: p. 285] In every system, there exists some amount of interplay and dependence between all of the performance elements in the system. However, this doesn't detract from the overall value of the model, because focusing attention on each of the different performance elements creates a whole picture of the system that is useful in evaluating performance improvement actions.

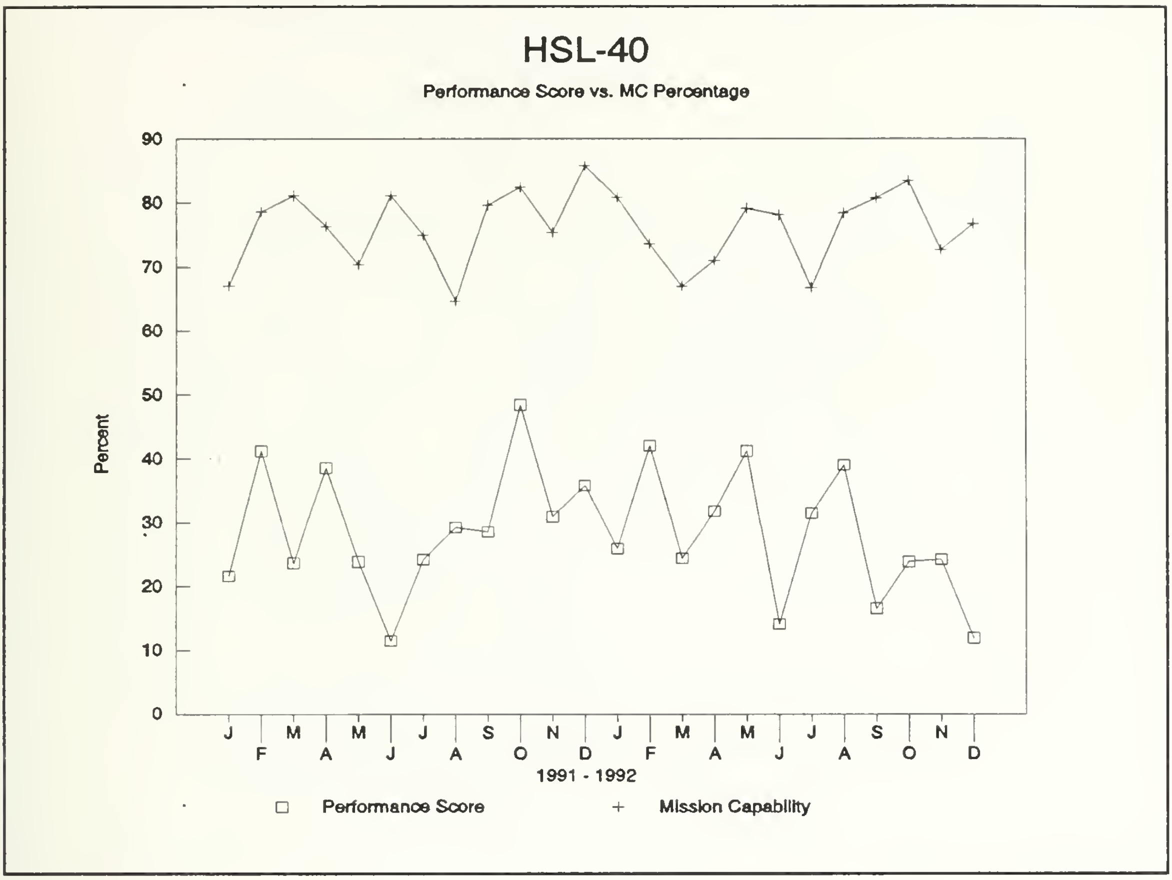

Figure 51

Second, the model is only as good as the information used. If the performance measures do not represent the performance improvement element or the data collection procedures are flawed, then the resulting performance score will be also flawed. However, this holds true with all measurement systems. As discovered from the interviews with the squadron maintenance officers, the current measures are capable of being gamed to improve the appearance of performance of the squadron.

Third, the model is a very simplistic snapshot of a very complex system. While this is true, it is also a major

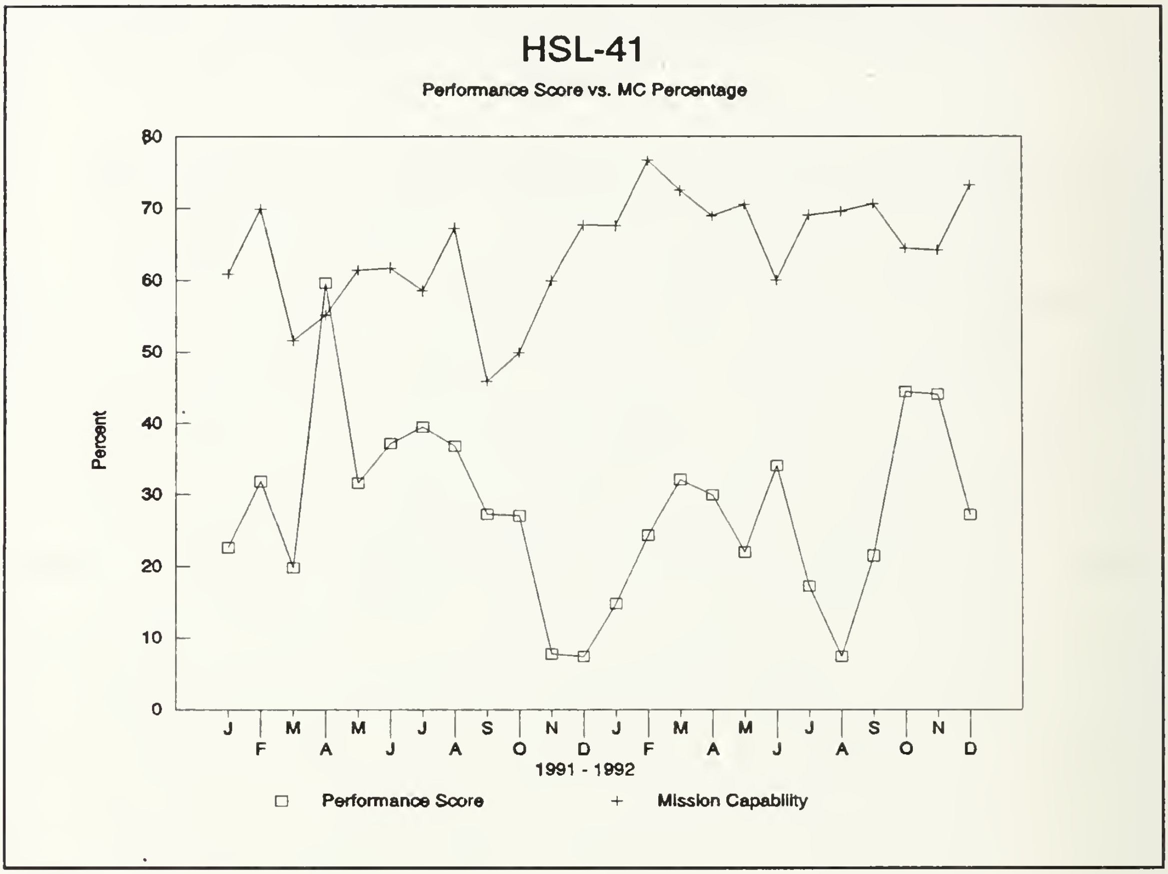

Figure 52

selling point. As no metrics currently exist for measuring aviation maintenance activities in the light of the seven performance improvement elements, this model will provide a starting point for developing a better understanding of the maintenance system.

D. OBSERVED OUTPUT OF THE MCP/PMT MODEL

The performance measure observations, listed in Figure 47, were applied to the performance matrix in Figure 50. The resulting performance score for each LAMPS MK III squadron surveyed was calculated for each month and graphed. The

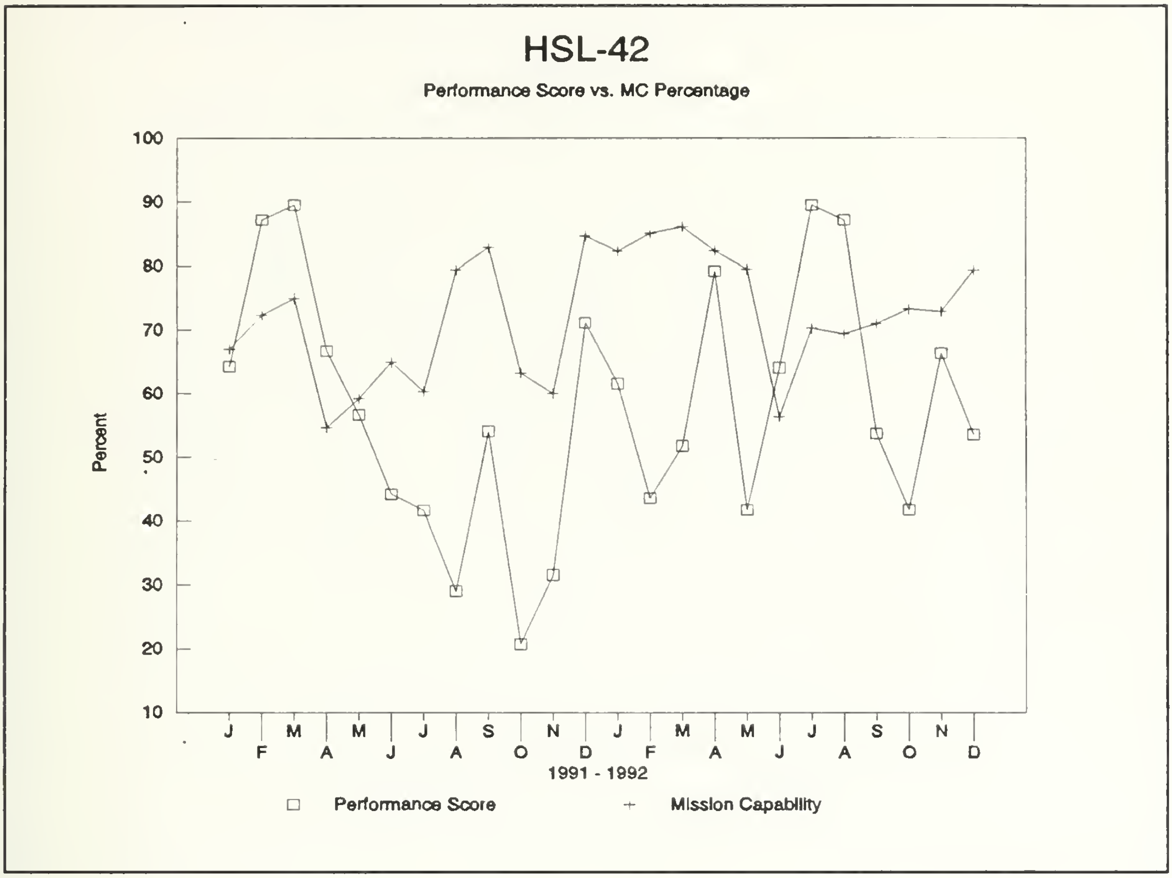

Figure 53

corresponding Mission Capability Percentage for the same period was included in the graph for contrast. The resulting graphs are Figure 51 through Figure 60.

At a minimum, two things can be noted from studying the graphs. The first is the wide disparity in the output of the MCP/PMT model for each squadron. An inference that might be drawn is that the maintenance system, in the context of Deming's philosophy, is out of control. This strongly reenforces the need to scrutinize the entire organizational level maintenance system and make efforts to improve its performance and to better utilize the resources available.

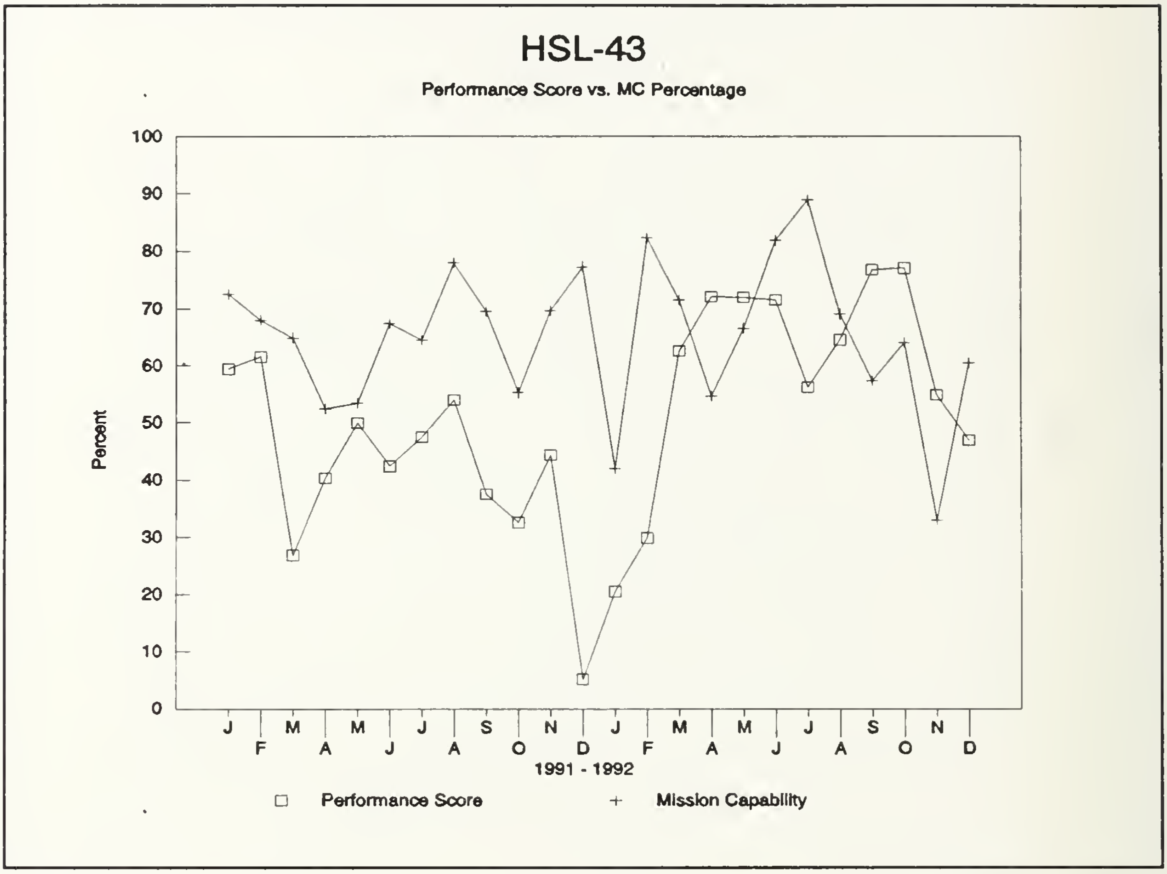

Figure 54

The second point that can be established from examining Figure 51 through Figure 60 is that there seems to be little correlation between the resulting MC rate and the performance score. While it might be argued that the performance measures used in the MCP/PMT model and the Objectives Matrix do not accurately reflect maintenance performance, it should be noted that the output of the model is a picture of how the resources available to the command were utilized to achieve the corresponding MC rate. This suggests that the usage of resources has little impact on the readiness of the squadron. More to the point, it becomes apparent that tremendous

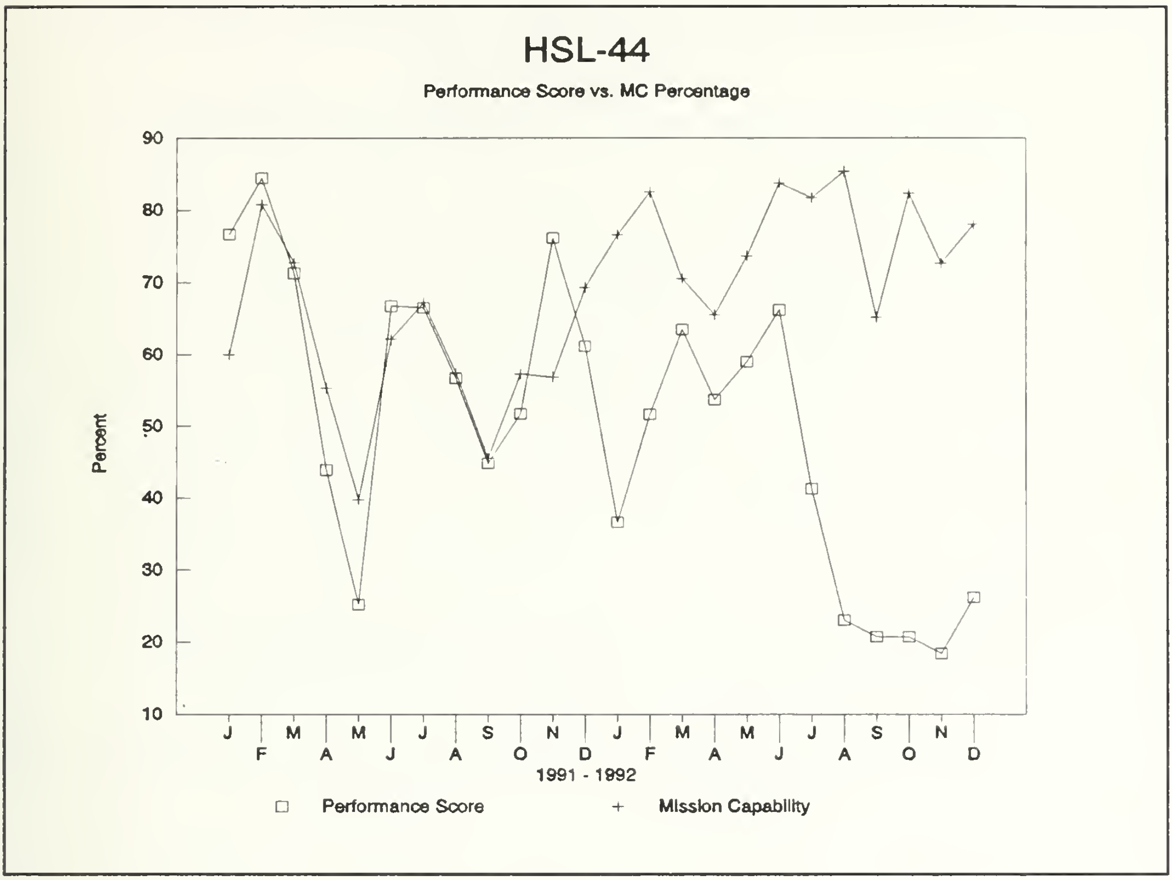

Figure 55

opportunities exist for improving the management of these resources and improving the performance of the maintenance department of the squadron.

E. SUMMARY

This chapter opened by enumerating several reasons for reevaluating the performance measures currently used in aviation maintenance. A discussion of the reasons for choosing the MCP/PMT model and Objectives Matrix followed. The steps required to utilize the MCP/PMT model were explained, and the model was demonstrated for each of the

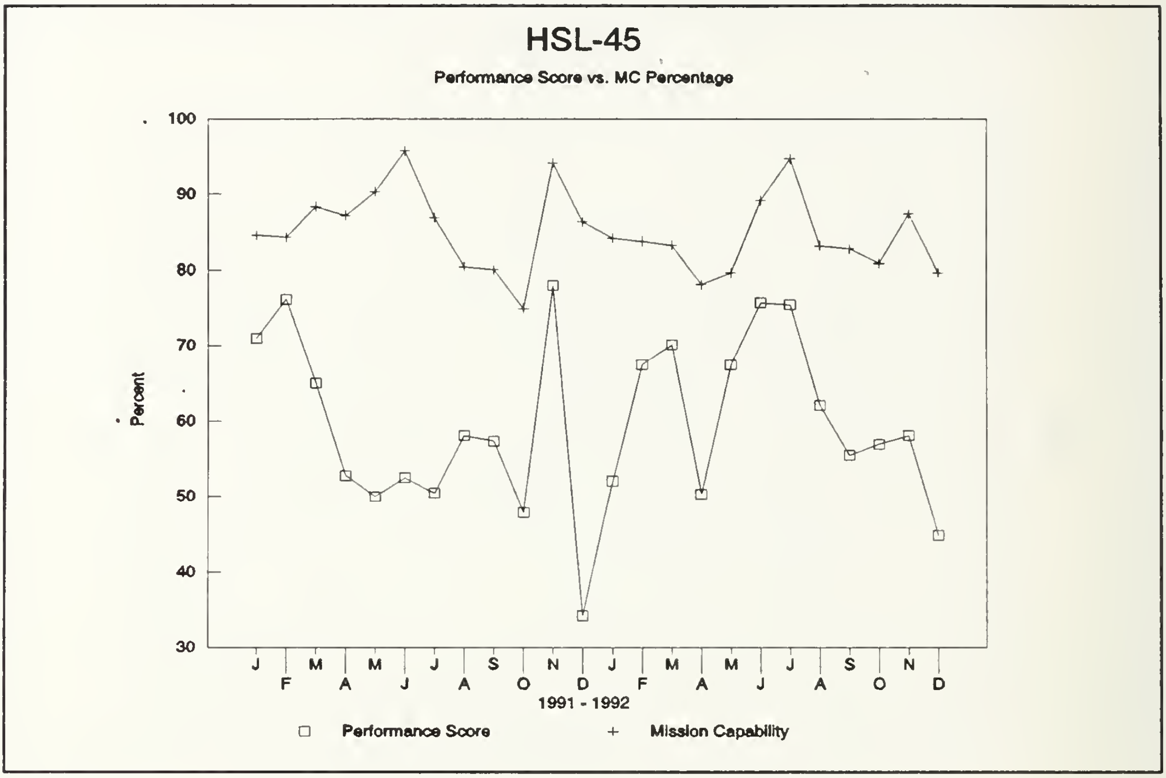

Figure 56

squadrons surveyed for the period between January 1991 to December 1992.

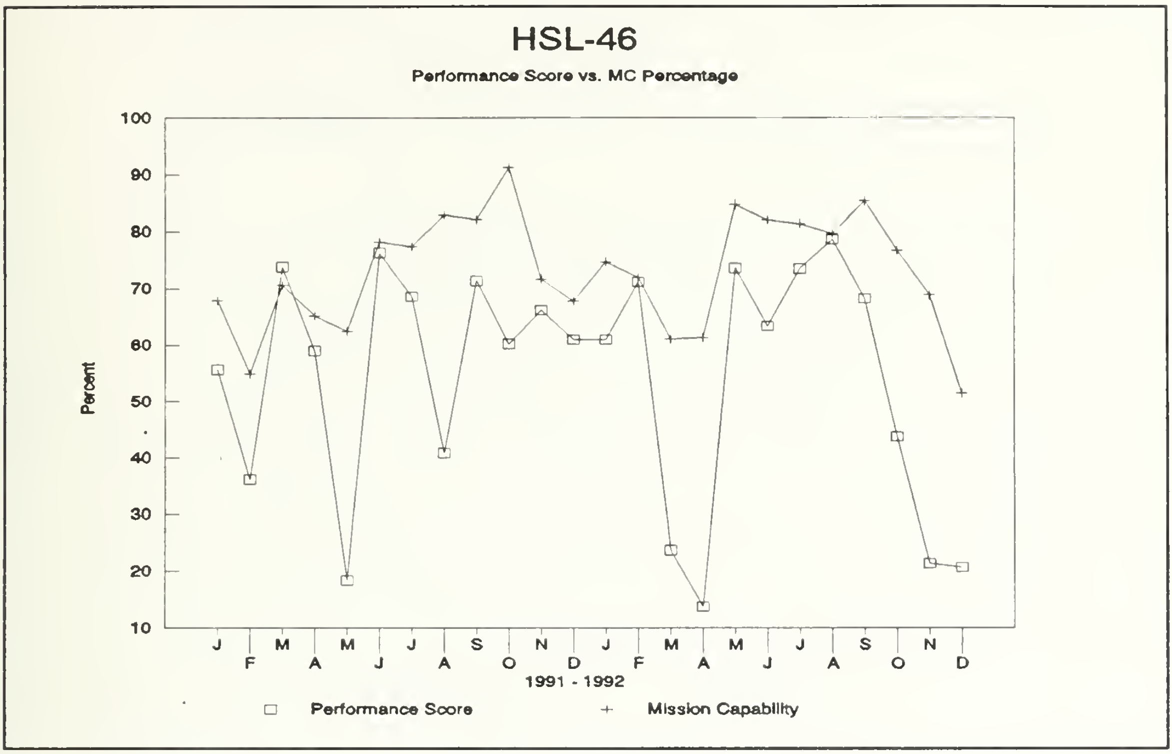

Figure 57

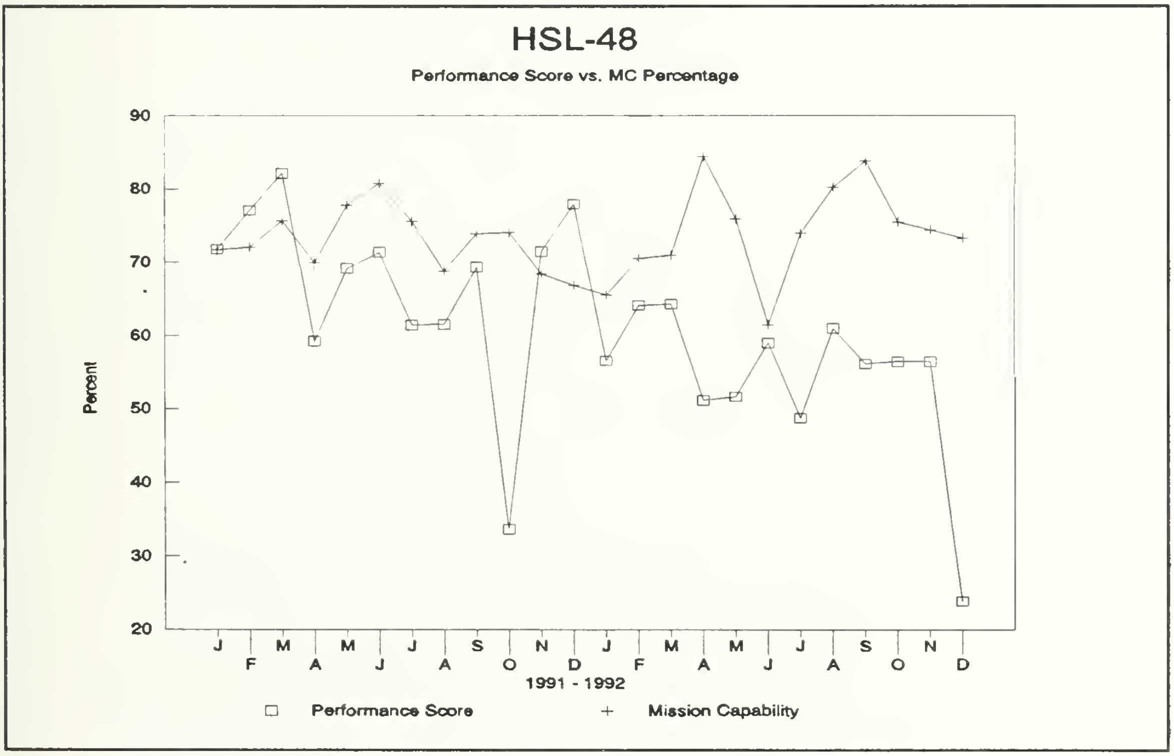

Figure 58

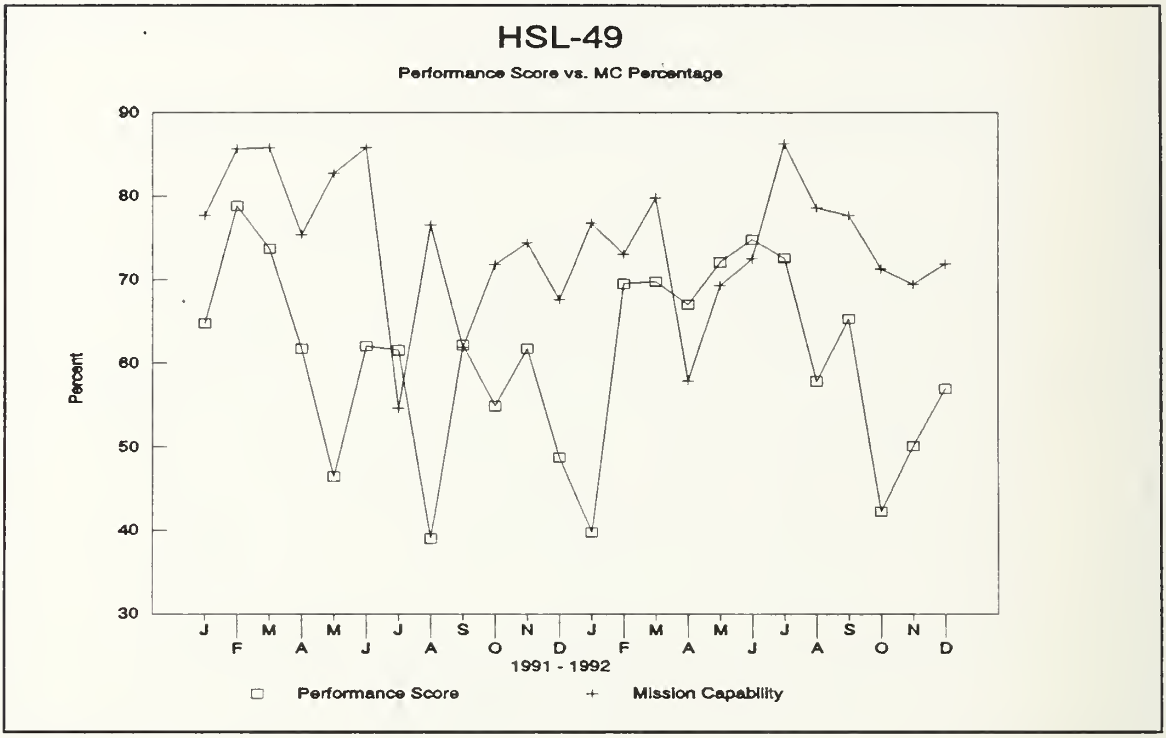

Figure 59

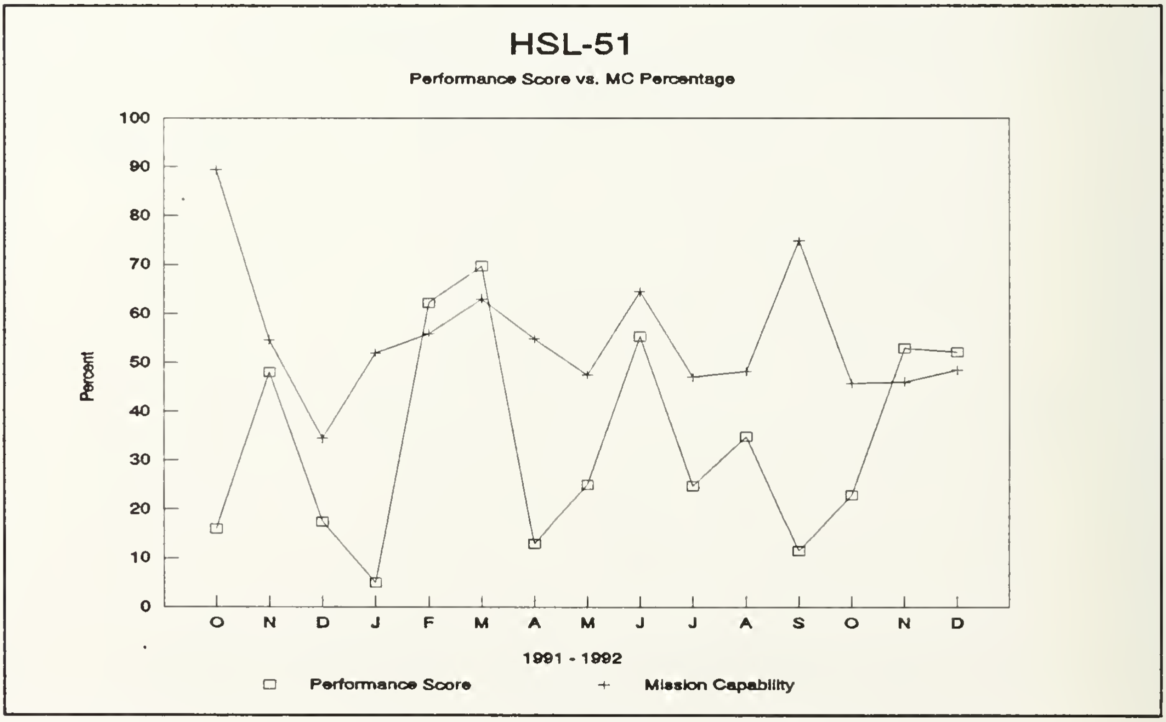

Figure 60

VII. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

In addition to planning and controlling the actions of a unit, it is necessary to measure its operating performance in order to effectively manage the organization or activity. Well developed performance measures provide the manager with effective tools for cultivating the highest level of performance from his department, and achieving the squadron's objectives, without sacrificing his people or the quality of the maintenance performed.

In Chapter III, the fundamental tenets of measuring performance within an organization were discussed. Performance improvement was further divided into seven elements: effectiveness; efficiency; productivity; quality; budgetability; quality of work life; and innovation. In addition, the fundamental concepts behind the MCP/PMT model and Objective Matrix were introduced as a vehicle for incorporating the seven improvement elements into a single measure. However, three improvement elements were not analyzed due to lack of data.

In Chapters IV and V, a multitude of performance measures were enumerated and described. As was feasible, each performance measure was analyzed using a variety of statistical tests. For the budgetability element, linear

regression was attempted to evaluate the relationship between flight hours and AFM funds, and attempt to determine if an alternative to the current budgeting equation could be determined. However, it was determined that the data received was significantly flawed and thus a valid budgetability measure could not be generated. This was due to two reasons, the first concerning the accounting methods used to account for AFM expenditures. The division of the AFM funds supporting Atlantic/Second Fleet and Sixth Fleet operations, combined with the flight hour limitations, inserted insurmountable bias into the research figures. Compound the East Coast peculiarities with the unstructured AFM trough found at NAS North Island, and the possibility of developing reasonably accurate base data becomes almost impossible within the time constraints of this projects.

The steps required to used Multi-Criteria Performance/Productivity Measurement Technique and Objectives Matrix were delineated in Chapter VI. The Objectives Matrix was built using data received from interviews and evaluated. The resulting performance scores were plotted for each squadron and compared with the current maintenance measure, Mission Capability Percentage.

A. CONCLUSIONS

From the research conducted in this thesis, several conclusion can be advanced. First, the lack of depth of the

Mission Capability Rate for describing the performance of the maintenance department. The data analyzed by this thesis on performance measures indicated that there is little consistency of the unit's outputs figures. As a picture of the resources applied to the maintenance problems of a squadron, there appears to be little proportionality between the resources used to achieve a given performance level.

The second conclusion that can be formulated is that the way maintenance is managed and performance is measured requires further examination. This appraisal should be conducted by each squadron within the auspices of a broad re-evaluation of the entire maintenance system and its objectives. This need is evident from the general lack of understanding by the maintenance officers interviewed on the different performance improvement elements.

Third, the suggested MCP/PMT model and Objectives Matrix will provide a more comprehensive look at the manner by which the limited resources are apportioned in conducting maintenance. The current measure attempts to capture only the effectiveness element of the maintenance effort. Use of the MCP/PMT model and Objectives Matrix will focus attention on the neglected performance improvement elements which have been noted by the NAMP as an important factors in a squadron's performance improvement effort. Through the model, the squadron's maintenance leadership will become aware of the

impact of any performance improvement initiatives instituted.

B. RECOMMENDATIONS

Within the context of the research conducted in this thesis several recommendations are suggested. First, squadrons should examine maintenance activities in light of effectiveness, efficiency, productivity, quality, budgetability, innovation and quality of work life. This includes tracking maintenance department performance using the MCP/PMT and the Objectives Matrix to develop a performance score that can be traced over time to reflect gains made by the squadron in improving their performance. Each squadron maintenance department should track the information required for their performance measures to minimized any delay due to inherent lags in the MDR system.

However, the results of the model and matrix are not recommended for use as a method for evaluating the performance of the maintenance officer, or the maintenance department. If evaluations of this kind are absolutely necessary, the maintenance officer and the department should be evaluated on use of the model and any subsequent performance improvement programs initiated.

A third recommendation is that the Pacific Fleet LAMPS squadrons be given an AFM budget and thus be given positive control over all their resources. Control over their funds is

imperative if the maintenance officers are to effectively evaluate existing maintenance options with regards to cost and budget constraints. As the situation stands, the LAMPS squadron maintenance purchases are affected by factors beyond the control of the squadron's maintenance officer. In addition, every squadron should begin to compare their actual cost per flight hour with the budgeted rate. This would help establish the validity of the AFM budgeting procedure.

The last recommendation to be formulated by this study is to include a thorough explanation of performance measures in the NAMP, OPNAVINST 4790.2 (series). Consideration should be given to including the MCP/PMT model and Objectives Matrix, and a listing of some of the performance measures included in this work in Chapter 4, Data Analysis, of Volume V of the NAMP.

C. AREAS FOR FUTURE STUDY

During the course of research of this thesis several items emerged that should be studied. The first is the NAMSO maintenance database. The current level of accuracy needs to be established, the barriers to achieving 100 percent accuracy should be enumerated, and procedures to improve the validity of the information that support the NAMSO database should be developed.

A topic that proved to be a barrier to the achievement of the objectives of this thesis and thus should be addressed is

the manner by which AFM is apportioned on each coast. With the creation of HSLWPAC in the summer of 1993, the organizational hierarchies serving the East and West Coast LAMPS squadrons are now the same. If NAS North Island decides to continue its practice of not apportioning AFM funds to squadrons, the effect this practice has on the readiness of the LAMPS squadrons is worthy of examination.

The final area for study is the applicability of the Multi-Criteria Productivity/Performance Measurement Technique and the Objectives Matrix to other naval activities. The possibility exists for this model to provide an effective tool for managing the performance of squadrons in other aviation communities as well as surface combatants and shore commands.

APPENDIX A

The primary functions of the squadron maintenance officer are as follows:

a. Administer the operation of the maintenance department in accordance with the NAMP.

b. Employ sound management practices in the handling of personnel, facilities, and material.

c. Define and assign responsibilities, functions, and operations in accordance with existing directives.

d. Initiate requests for, and make recommendations relative to, changes concerning personnel, facilities, and equipment required to accomplish assigned tasks.

e. Ensure the accomplishment of training for permanently and temporarily assigned personnel.

f. Analyze the mission of the department and ensure that timely planning is conducted and a statement of requirements to meet future needs is initiated.

g. Ensure full and effective employment of assigned personnel.

h. Ensure that the productions output of the department is of proper quantity and quality on accordance with applicable specifications and directives.

i. Maintain liaison with other department heads and representatives of higher authority and other maintenance organizations, for example, attendance at monthly intermediated maintenance activity (IMA) supply maintenance meetings.

j. Publish and ensure internal compliance with maintenance, safety, and security procedures to ensure optimum performance is achieved.

k. Scheduling and holding periodic planning and informal meetings with all officers and senior petty officers/noncommissioned officers.

l. Ensure the monitoring of all maintenance programs, for example, fuel, hydraulic and oil contamination, foreign object damage, corrosion control, and nondestructive inspection.

m. Provide data analysis summaries to the CO and other superiors in the chain of command when they are requested.

n. Ensure the IMRL[9] is frequently reviewed and necessary changes submitted, accurate equipage records are maintained, and required reports are submitted.

o. Ensure the NMCS/PMCS[10] status listing is validated, certified, and returned to supply on a daily basis.

p. Ensure the efficient operations of the Maintenance Data System (MDS).

q. Ensure that the applicable publications and directives are disseminated throughout the maintenance department.

r. Recommend qualified candidates for engine turnup licensing (fixed and rotary wing).

s. Participate on the plane captain selection and examining board.

t. Ensure that local instructions and procedures are compatible with MDS.

u. Ensure that each work center supervisor thoroughly understands the importance of the MDS, its operation, and the need for continual accuracy.

---

[9]Individual Material Readiness List (IMRL). A consolidated list showing items and quantities of certain SE required for material readiness of the aircraft ground activity to which the list applies. OPNAVINST 4790.2E, Vol. II, Appendix C, p. 3.

[10]NMCS/PMCS is Not Mission Capable - Supply (NMCS) or Partial Mission Capable - Supply (PMCS). It refers to a mission capability designation for aircraft that are either unable to fly or unable to perform a specific mission because of there is an outstanding requisition for parts against the aircraft.

v. Ensure that supervisory and quality assurance (QA) personnel are thoroughly familiar with compass calibration requirements in accordance with MIL-STD-765A (NOTAL).

w. Use maintenance management teams, as required, in support of efficient maintenance material practices by the maintenance department.

x. Use the on site Naval Air Systems Command (NAVAIR)/Naval Aviation Engineering Services Unit field service representatives, as required, to effect liaison and support for the NAMP."[Ref. 2: p. 3-5]

APPENDIX B

Aviation Fleet Maintenance funds can be used to finance the cost of the following:

a. "Paints, wiping rags, towel service, cleaning agent, and cutting compounds used in preventative maintenance and corrosion control of aircraft.

b. Consumable repair parts, miscellaneous material, and Navy stock account parts used in direct maintenance of aircraft including repair and replacement of AVDLRs and related SE[11].

c. Pre-existing, consumable maintenance material meeting requirements of NAVSUP Publication 485 (NOTAL) used in maintenance of aircraft, aviation components, or SE.

d. Aviation fuels used at I-level in test and check of aircraft engines during engine buildup, change, or during maintenance. Oils, lubricants, and fuel additives used at both O- and I-level.

e. Allowance list items (NA 00-35QH series (NOTAL)) used strictly for maintenance, such as, aprons (impermeable), coveralls (explosive handlers), face shields (industrial), gloves (gas welders), goggles (industrial), and nonprescription safety glasses.

f. Fuels used in related SE (shipboard only).

g. Replacement of components used in test bench repair.

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[11]SE is Support Equipment. All Individual Material Readiness List (IMRL) and nonIMRL equipment required to make an aeronautical system, command and control system, support system, subsystem, or end item of equipment (SE for SE) operational in its intended environment. [Ref. 2: p. C-33]

h. Maintenance or equipment replacement of aircraft loose equipment listed in the AIR[12].

i. Consumable hand tools used in the readiness and maintenance of aircraft, maintenance and repair of components, and related equipment.

j. Safety and flight deck shoes used in maintenance shops.

k. Repair and maintenance of flight clothing and pilots and crew equipment.

l. Authorized decals used on aircraft.

m. Replacement of consumable tools and IMRL allowance items.

n. Items consumed in interim packaging/preservation of aviation fleet maintenance repairables.

o. Items, such as VIDS/MAFs, MAF bags, equipment condition tags, and COG 11 forms, and publications, used in support of direct maintenance of aviation components or aircraft.

p. Authorized special purpose clothing for unusually dirty work while performing maintenance of aircraft.

q. Civilian labor only when used in direct support of aviation fleet maintenance.

r. Costs incurred for IMRL repair.

s. Replacement of general purpose electronic test equipment (GPETE) allowance items which are missing or unserviceable (COG Z).

t. Oils, lubricants, and fuel additives consumed during flight operations.

u. Navy stock account repairable material (nonAVDLR) used in direct maintenance of aircraft component repair, or related SE.

v. The requisitioning of material incidental to TD installation, for example, fluids, epoxies, and shelf life

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[12]AIR is Aircraft Inventory Reporting system. The AIR is a list of serialized equipment installed on the aircraft.

items, not to exceed one thousand dollars per TD per squadron.[Ref. 2: pp. 6-132,133]

APPENDIX C

MISSION CAPABILITY PERCENTAGE
(Effectiveness)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	71.300	11.665			
FRS	48	70.05	9.14			
SEA	183	71.627	12.243			
LANT	120	72.652	9.299			
PAC	111	69.84	13.67			
LANT-Sea	96	71.79	9.82			
PAC-Sea	87	71.45	14.52			
HSL-40	24	76.09	5.82	3.39	45	1.645
HSL-41	24	64.03	7.79	-4.12	34	1.645
HSL-42	24	72.15	9.77	0.40	30	1.645
HSL-43	24	65.17	12.82	-2.25	27	1.703
HSL-44	24	68.42	12.32	-1.10	27	1.703
HSL-45	24	85.01	5.31	10.31	50	1.645
HSL-46	24	73.01	10.19	0.77	29	1.699
HSL-48	24	73.58	5.50	1.68	48	1.645
HSL-49	24	74.33	8.40	1.62	33	1.645
HSL-51	15	55.17	13.46	-4.53	15	1.753

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	11766.5	1307.4	14.79	0.000	2.41
ERROR	221	19534.9	88.4			
TOTAL	230	31301.4				

```
                                          INDIVIDUAL 95 PCT CI'S FOR MEAN
                                          BASED ON POOLED STDEV
LEVEL       N      MEAN     STDEV   ---------+---------+---------+-------
HSL-40     24    76.090     5.822                       (--*---)
HSL-41     24    64.030     7.795             (--*---)
HSL-42     24    72.150     9.767                    (--*--)
HSL-43     24    65.167    12.822              (--*--)
HSL-44     24    68.421    12.322                 (--*--)
HSL-45     24    85.005     5.315                               (--*--)
HSL-46     24    73.011    10.190                     (--*--)
HSL-48     24    73.582     5.496                     (--*--)
HSL-49     24    74.334     8.398                      (--*--)
HSL-51     15    55.167    13.458    (---*---)
                                    ---------+---------+---------+-------
POOLED STDEV =    9.402                     60        72        84
```

	z	$z_{0.05}$
FRS vs. SEA:	-0.983453	1.645
LANT vs. PAC:	1.81369	1.645
LANT-Sea vs. PAC-Sea:	0.186782	1.645

OPTIMUM CAPABILITY PERCENTAGE
(Effectiveness)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	88.085	6.592			
FRS	48	86.517	4.561			
SEA	183	88.496	6.980			
LANT	120	89.456	4.300			
PAC	111	86.603	8.159			
LANT-Sea	96	89.799	4.317			
PAC-Sea	87	87.059	8.862			
HSL-40	24	88.079	4.030	-0.01	37	1.645
HSL-41	24	84.950	4.600	-3.03	33	1.645
HSL-42	24	88.07	5.15	-0.01	31	1.645
HSL-43	24	83.36	7.25	-3.06	27	1.703
HSL-44	24	89.821	4.141	1.83	36	1.645
HSL-45	24	94.439	2.558	9.36	62	1.645
HSL-46	24	91.286	4.339	3.25	35	1.645
HSL-48	24	90.008	3.009	2.56	50	1.645
HSL-49	24	89.972	3.582	2.22	41	1.645
HSL-51	15	76.52	10.68	-4.14	14	1.761

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	4237.7	470.9	18.07	0.000	2.41
ERROR	221	5757.5	26.1			
TOTAL	230	9995.2				

```
                                         INDIVIDUAL 95 PCT CI'S FOR MEAN
                                         BASED ON POOLED STDEV
LEVEL          N      MEAN      STDEV   -----+---------+---------+---------+-
HSL-40        24    88.079      4.030                     (--*--)
HSL-41        24    84.950      4.600                (--*--)
HSL-42        24    88.073      5.152                     (--*--)
HSL-43        24    83.362      7.248              (--*--)
HSL-44        24    89.821      4.141                       (--*--)
HSL-45        24    94.439      2.558                              (--*--)
HSL-46        24    91.286      4.339                         (--*--)
HSL-48        24    90.008      3.009                        (--*--)
HSL-49        24    89.972      3.582                        (--*-)
HSL-51        15    76.523     10.682    (--*---)
                                        -----+---------+---------+---------+-
POOLED STDEV =       5.104                  77.0      84.0      91.0      98.0
```

	z	$z_{0.05}$
FRS vs. SEA:	-2.36657	1.645
LANT vs. PAC:	3.28603	1.645
LANT-Sea vs. PAC-Sea:	2.61672	1.645

MISSION CAPABILITY/OPTIMUM CAPABILITY RATIO
(Effectiveness)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	80.594	9.482			
FRS	48	80.81	8.28			
SEA	183	80.537	9.792			
LANT	120	81.080	8.540			
PAC	111	80.070	10.419			
LANT-Sea	96	79.765	8.817			
PAC-Sea	87	81.39	10.75			
HSL-40	24	86.338	4.485	5.18	48	1.645
HSL-41	24	75.29	7.51	-3.20	31	1.645
HSL-42	24	81.66	7.57	0.64	31	1.645
HSL-43	24	77.55	10.44	-1.37	27	1.703
HSL-44	24	75.89	11.81	-1.89	26	1.706
HSL-45	24	90.00	4.98	7.89	43	1.645
HSL-46	24	79.77	8.63	-0.44	29	1.699
HSL-48	24	81.73	5.14	0.93	41	1.645
HSL-49	24	82.52	7.82	1.12	30	1.645
HSL-51	15	71.94	11.81	-2.78	15	1.753

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	5633.1	625.9	9.19	0.000	2.41
ERROR	221	15044.7	68.1			
TOTAL	230	20677.8				

```
                                   INDIVIDUAL 95 PCT CI'S FOR MEAN
                                   BASED ON POOLED STDEV
LEVEL       N      MEAN     STDEV  ----+---------+---------+---------+--
HSL-40     24    86.338     4.485                         (---*----)
HSL-41     24    75.289     7.513         (----*---)
HSL-42     24    81.662     7.571                  (----*---)
HSL-43     24    77.550    10.442            (----*----)
HSL-44     24    75.893    11.812          (---*----)
HSL-45     24    90.005     4.977                             (----*---)
HSL-46     24    79.775     8.627               (----*----)
HSL-48     24    81.731     5.141                  (----*----)
HSL-49     24    82.517     7.819                   (----*----)
HSL-51     15    71.937    11.812   (-----*-----)
                                   ----+---------+---------+---------+--
POOLED STDEV =    8.251              70.0      77.0      84.0      91.0
```

	z	$z_{0.05}$
FRS vs. SEA:	0.197844	1.645
LANT vs. PAC:	0.802422	1.645
LANT-Sea vs. PAC-Sea:	-1.10977	1.645

SORTIE EXECUTION RATIO
(Effectiveness)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	93.349	4.349			
FRS	48	92.162	3.210			
SEA	183	93.660	4.557			
LANT	120	93.437	4.904			
PAC	111	93.254	3.675			
LANT-Sea	96	93.648	5.240			
PAC-Sea	87	93.673	3.691			
HSL-40	24	92.592	3.177	-1.07	32	1.645
HSL-41	24	91.732	3.253	-2.24	32	1.645
HSL-42	24	94.665	2.327	2.37	42	1.645
HSL-43	24	93.630	2.379	0.50	41	1.645
HSL-44	24	93.60	6.00	0.20	25	1.708
HSL-45	24	95.496	2.133	4.12	46	1.645
HSL-46	24	94.08	5.39	0.65	26	1.706
HSL-48	24	94.380	2.845	1.59	35	1.645
HSL-49	24	94.637	2.005	2.58	49	1.645
HSL-51	15	89.29	5.69	-2.71	15	1.753

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	546.8	60.8	4.38	0.000	2.41
ERROR	221	3064.5	13.9			
TOTAL	230	3611.3				

```
                                     INDIVIDUAL 95 PCT CI'S FOR MEAN
                                     BASED ON POOLED STDEV
LEVEL      N      MEAN     STDEV     ---------+---------+---------+-------
HSL-40    24    92.592     3.177                  (----*----)
HSL-41    24    91.732     3.253               (----*----)
HSL-42    24    94.665     2.327                         (----*----)
HSL-43    24    93.630     2.379                     (----*----)
HSL-44    24    93.603     6.001                     (----*----)
HSL-45    24    95.496     2.133                           (----*----)
HSL-46    24    94.084     5.394                       (----*----)
HSL-48    24    94.380     2.845                        (----*----)
HSL-49    24    94.637     2.005                        (----*----)
HSL-51    15    89.285     5.691     (------*-----)
                                     ---------+---------+---------+-------
POOLED STDEV =    3.724                     90.0      93.0      96.0
```

	z	$z_{0.05}$
FRS vs. SEA:	-2.61568	1.645
LANT vs. PAC:	0.323455	1.645
LANT-Sea vs. PAC-Sea:	-0.0376027	1.645

UTILIZATION RATE
(Effectiveness)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	10.474	3.766			
FRS	48	7.189	2.076			
SEA	183	11.336	3.636			
LANT	120	10.080	4.001			
PAC	111	10.901	3.461			
LANT-Sea	96	10.911	3.977			
PAC-Sea	87	11.805	3.174			
HSL-40	24	6.755	1.755	-8.54	49	1.645
HSL-41	24	7.623	2.309	-5.36	37	1.645
HSL-42	24	12.500	3.896	2.43	27	1.703
HSL-43	24	11.798	3.227	1.88	29	1.699
HSL-44	24	10.50	5.03	0.03	25	1.708
HSL-45	24	11.631	2.524	2.02	34	1.645
HSL-46	24	9.314	3.439	-1.56	29	1.699
HSL-48	24	11.328	2.710	1.41	33	1.645
HSL-49	24	12.357	3.143	2.74	30	1.645
HSL-51	15	11.21	4.14	0.67	15	1.753

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	842.7	93.6	8.55	0.000	2.41
ERROR	221	2419.4	10.9			
TOTAL	230	3262.1				

```
                                            INDIVIDUAL 95 PCT CI'S FOR MEAN
                                            BASED ON POOLED STDEV
LEVEL          N      MEAN      STDEV   ---------+---------+---------+-------
HSL-40        24     6.755      1.755    (----*----)
HSL-41        24     7.623      2.309       (----*-----)
HSL-42        24    12.500      3.896                          (----*----)
HSL-43        24    11.798      3.227                       (----*-----)
HSL-44        24    10.504      5.034                  (----*----)
HSL-45        24    11.631      2.524                      (-----*----)
HSL-46        24     9.314      3.439             (----*-----)
HSL-48        24    11.328      2.710                     (----*-----)
HSL-49        24    12.357      3.143                         (----*-----)
HSL-51        15    11.211      4.138                   (------*------)
                                        ---------+---------+---------+-------
POOLED STDEV =       3.309                      7.5      10.0      12.5
```

	z	$z_{0.05}$
FRS vs. SEA:	-10.3038	1.645
LANT vs. PAC:	-1.67003	1.645
LANT-Sea vs. PAC-Sea:	-1.68677	1.645

LABOR UTILIZATION RATE
(Efficiency)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	954.3	382.3			
FRS	48	890.0	199.2			
SEA	183	971.2	416.0			
LANT	120	1158.9	382.7			
PAC	111	733.2	228.4			
LANT-Sea	96	1206.0	400.1			
PAC-Sea	87	712.0	244.8			
HSL-40	24	970.1	223.6	0.30	38	1.645
HSL-41	24	809.8	133.0	-3.90	74	1.645
HSL-42	24	1663.2	303.4	10.61	31	1.645
HSL-43	24	900.4	227.8	-1.02	38	1.645
HSL-44	24	1302.2	270.0	5.74	33	1.645
HSL-45	24	805.0	125.3	-4.16	81	1.645
HSL-46	24	1088.5	164.3	3.20	54	1.645
HSL-48	24	770.3	170.4	-4.29	51	1.645
HSL-49	24	546.5	150.4	-10.28	61	1.645
HSL-51	15	526.7	245.9	-6.26	18	1.734

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	24054984	2672776	61.78	0.000	2.41
ERROR	221	9560742	43261			
TOTAL	230	33615728				

```
                                       INDIVIDUAL 95 PCT CI'S FOR MEAN
                                       BASED ON POOLED STDEV
LEVEL        N      MEAN     STDEV   ----------+---------+---------+------
HSL-40      24     970.1     223.6               (-*-)
HSL-41      24     809.8     133.0           (-*-)
HSL-42      24    1663.2     303.4                                (--*-)
HSL-43      24     900.4     227.8             (--*-)
HSL-44      24    1302.2     270.0                       (--*-)
HSL-45      24     805.0     125.3           (-*-)
HSL-46      24    1088.5     164.3                  (-*-)
HSL-48      24     770.3     170.4          (-*-)
HSL-49      24     546.5     150.4     (-*-)
HSL-51      15     526.7     245.9    (-*--)
                                     ----------+---------+---------+------
POOLED STDEV =     208.0                      800      1200      1600
```

	z	$z_{0.05}$
FRS vs. SEA:	-1.92876	1.645
LANT vs. PAC:	10.3535	1.645
LANT-Sea vs. PAC-Sea:	10.1771	1.645

MAINTENANCE MAN-HOUR RATIO
(Efficiency)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	0.6183	0.3142			
FRS	48	0.7591	0.2521			
SEA	183	0.5813	0.3190			
LANT	120	0.3939	0.1795			
PAC	111	0.8608	0.2394			
LANT-Sea	96	0.3483	0.1587			
PAC-Sea	87	0.8385	0.2450			
HSL-40	24	0.5763	0.1389	-1.20	52	1.645
HSL-41	24	0.9418	0.2022	7.01	35	1.645
HSL-42	24	0.2453	0.0911	-13.42	99	1.645
HSL-43	24	0.8320	0.2732	3.59	29	1.699
HSL-44	24	0.3497	0.1591	-6.98	44	1.645
HSL-45	24	0.8612	0.2076	5.15	35	1.645
HSL-46	24	0.2638	0.0800	-13.45	123	1.645
HSL-48	24	0.5343	0.0973	-2.93	89	1.645
HSL-49	24	0.7730	0.1729	3.78	41	1.645
HSL-51	15	0.9174	0.3335	3.38	15	1.753

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	15.2383	1.6931	50.07	0.000	2.41
ERROR	221	7.4734	0.0338			
TOTAL	230	22.7118				

```
                                   INDIVIDUAL 95 PCT CI'S FOR MEAN
                                   BASED ON POOLED STDEV
LEVEL        N     MEAN     STDEV  ----+---------+---------+---------+--
HSL-40      24   0.5763    0.1389                (--*--)
HSL-41      24   0.9418    0.2022                               (--*--)
HSL-42      24   0.2453    0.0911   (--*--)
HSL-43      24   0.8320    0.2732                          (--*--)
HSL-44      24   0.3497    0.1591       (--*--)
HSL-45      24   0.8612    0.2076                           (--*--)
HSL-46      24   0.2638    0.0800    (--*--)
HSL-48      24   0.5343    0.0973              (--*--)
HSL-49      24   0.7730    0.1729                       (--*--)
HSL-51      15   0.9174    0.3335                             (---*--)
                                   ----+---------+---------+---------+--
POOLED STDEV =   0.1839               0.25      0.50      0.75      1.00
```

	z	$z_{0.05}$
FRS vs. SEA:	4.09915	1.645
LANT vs. PAC:	-16.6685	1.645
LANT-Sea vs. PAC-Sea:	-15.8857	1.645

SCHEDULED DIRECT MAN-HOUR RATIO
(Efficiency)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	0.64088	0.12155			
FRS	48	0.5796	0.0801			
SEA	183	0.65696	0.12555			
LANT	120	0.72883	0.09021			
PAC	111	0.54580	0.06729			
LANT-Sea	96	0.75129	0.08311			
PAC-Sea	87	0.55288	0.06958			
HSL-40	24	0.6390	0.0553	-0.13	50	1.645
HSL-41	24	0.5201	0.0517	-9.12	55	1.645
HSL-42	24	0.8071	0.0575	11.70	48	1.645
HSL-43	24	0.5573	0.0824	-4.49	34	1.645
HSL-44	24	0.7496	0.0781	6.09	35	1.645
HSL-45	24	0.5432	0.0564	-6.96	49	1.645
HSL-46	24	0.7942	0.0495	11.90	58	1.645
HSL-48	24	0.65425	0.04082	1.16	78	1.645
HSL-49	24	0.5690	0.0532	-5.33	53	1.645
HSL-51	15	0.5355	0.0880	-4.38	17	1.740

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	2.55247	0.28361	74.10	0.000	2.41
ERROR	221	0.84580	0.00383			
TOTAL	230	3.39827				

```
                                          INDIVIDUAL 95 PCT CI'S FOR MEAN
                                          BASED ON POOLED STDEV
LEVEL        N      MEAN     STDEV   -+---------+---------+---------+-----
HSL-40      24   0.63903   0.05526               (--*-)
HSL-41      24   0.52011   0.05172    (-*--)
HSL-42      24   0.80705   0.05748                              (--*-)
HSL-43      24   0.55733   0.08236       (--*-)
HSL-44      24   0.74960   0.07813                        (--*-)
HSL-45      24   0.54323   0.05645      (-*--)
HSL-46      24   0.79424   0.04953                             (-*--)
HSL-48      24   0.65425   0.04082                 (-*--)
HSL-49      24   0.56898   0.05324        (--*-)
HSL-51      15   0.53545   0.08798    (---*--)
                                     -+---------+---------+---------+-----
POOLED STDEV =   0.06186             0.50      0.60      0.70      0.80
```

	z	$z_{0.05}$
FRS vs. SEA:	-5.22044	1.645
LANT vs. PAC:	17.5640	1.645
LANT-Sea vs. PAC-Sea:	17.5643	1.645

UNSCHEDULED DIRECT MAN-HOUR PERCENTAGE
(Efficiency)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	35.909	12.154			
FRS	48	42.04	8.01			
SEA	183	34.300	12.554			
LANT	120	27.117	9.021			
PAC	111	45.414	6.734			
LANT-Sea	96	24.871	8.311			
PAC-Sea	87	44.704	6.963			
HSL-40	24	36.10	5.53	0.14	50	1.645
HSL-41	24	47.99	5.17	9.12	55	1.645
HSL-42	24	19.29	5.75	-11.70	48	1.645
HSL-43	24	44.24	8.25	4.47	34	1.645
HSL-44	24	25.04	7.81	-6.09	35	1.645
HSL-45	24	45.68	5.64	6.96	49	1.645
HSL-46	24	20.58	4.95	-11.89	58	1.645
HSL-48	24	34.575	4.082	-1.15	78	1.645
HSL-49	24	43.10	5.32	5.33	53	1.645
HSL-51	15	46.45	8.80	4.38	17	1.740

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	25513.0	2834.8	74.02	0.000	2.41
ERROR	221	8463.9	38.3			
TOTAL	230	33976.9				

```
                                           INDIVIDUAL 95 PCT CI'S FOR MEAN
                                           BASED ON POOLED STDEV
LEVEL        N      MEAN      STDEV   ----+---------+---------+---------+--
HSL-40      24    36.097      5.526                   (-*--)
HSL-41      24    47.989      5.172                              (--*-)
HSL-42      24    19.295      5.748    (-*--)
HSL-43      24    44.238      8.252                           (-*--)
HSL-44      24    25.040      7.813         (-*--)
HSL-45      24    45.677      5.645                            (--*-)
HSL-46      24    20.576      4.953     (--*-)
HSL-48      24    34.575      4.082                 (--*-)
HSL-49      24    43.102      5.324                          (-*--)
HSL-51      15    46.455      8.798                            (--*---)
                                      ----+---------+---------+---------+--
POOLED STDEV =    6.189                  20        30        40        50
```

	z	$z_{0.05}$
FRS vs. SEA:	5.22332	1.645
LANT vs. PAC:	-17.5530	1.645
LANT-Sea vs. PAC-Sea:	-17.5512	1.645

SCIR-MAINTENANCE RATIO
(Efficiency)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	0.9434	1.1278			
FRS	48	1.144	0.822			
SEA	183	0.8909	1.1914			
LANT	120	0.5742	0.3711			
PAC	111	1.343	1.484			
LANT-Sea	96	0.5717	0.3985			
PAC-Sea	87	1.243	1.609			
HSL-40	24	0.5842	0.2378	-4.05	165	1.645
HSL-41	24	1.703	0.820	4.15	32	1.645
HSL-42	24	0.5033	0.3532	-4.25	87	1.645
HSL-43	24	1.756	1.780	2.19	24	1.645
HSL-44	24	0.5038	0.3751	-4.12	79	1.645
HSL-45	24	0.3567	0.2151	-6.80	188	1.645
HSL-46	24	0.6062	0.4369	-2.91	62	1.645
HSL-48	24	0.6733	0.4217	-2.38	66	1.645
HSL-49	24	0.7513	0.3072	-1.98	110	1.645
HSL-51	15	2.627	2.490	2.60	14	1.761

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	98.247	10.916	12.42	0.000	2.41
ERROR	221	194.319	0.879			
TOTAL	230	292.566				

```
                                         INDIVIDUAL 95 PCT CI'S FOR MEAN
                                         BASED ON POOLED STDEV
LEVEL       N      MEAN     STDEV    -+---------+---------+---------+-----
HSL-40     24    0.5842    0.2378       (---*---)
HSL-41     24    1.7029    0.8203                  (---*---)
HSL-42     24    0.5033    0.3532      (---*---)
HSL-43     24    1.7563    1.7803                   (---*--)
HSL-44     24    0.5038    0.3751      (---*---)
HSL-45     24    0.3567    0.2151     (---*--)
HSL-46     24    0.6062    0.4369       (---*---)
HSL-48     24    0.6733    0.4217        (---*---)
HSL-49     24    0.7513    0.3072         (---*--)
HSL-51     15    2.6273    2.4903                          (---*----)
                                     -+---------+---------+---------+-----
POOLED STDEV =   0.9377              0.0       1.0       2.0       3.0
```

	z	$z_{0.05}$
FRS vs. SEA:	1.70932	1.645
LANT vs. PAC:	-5.30487	1.645
LANT-Sea vs. PAC-Sea:	-3.78814	1.645

TOTAL MAN-HOUR COVERAGE RATIO
(Efficiency)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	7.246	7.261			
FRS	48	4.444	1.543			
SEA	183	7.981	7.963			
LANT	120	7.880	4.376			
PAC	111	6.560	9.414			
LANT-Sea	96	8.527	4.621			
PAC-Sea	87	7.38	10.48			
HSL-40	24	5.296	1.467	-3.46	175	1.645
HSL-41	24	3.592	1.094	-6.93	231	1.645
HSL-42	24	9.07	5.33	1.53	32	1.645
HSL-43	24	4.645	1.736	-4.37	137	1.645
HSL-44	24	8.519	3.132	1.59	54	1.645
HSL-45	24	10.575	4.885	3.01	34	1.645
HSL-46	24	10.69	5.74	2.72	31	1.645
HSL-48	24	5.830	2.056	-2.23	103	1.645
HSL-49	24	4.970	1.509	-4.00	168	1.645
HSL-51	15	10.49	24.01	0.52	14	1.761

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	1573.7	174.9	3.66	0.000	2.41
ERROR	221	10553.9	47.8			
TOTAL	230	12127.5				

```
                                         INDIVIDUAL 95 PCT CI'S FOR MEAN
                                         BASED ON POOLED STDEV
LEVEL        N      MEAN     STDEV      --------+---------+---------+-------
HSL-40      24     5.296     1.467          (------*------)
HSL-41      24     3.592     1.094      (------*------)
HSL-42      24     9.070     5.331                    (------*------)
HSL-43      24     4.645     1.736         (------*------)
HSL-44      24     8.519     3.132                  (------*------)
HSL-45      24    10.575     4.885                       (------*------)
HSL-46      24    10.687     5.742                        (------*------)
HSL-48      24     5.830     2.056            (------*------)
HSL-49      24     4.970     1.509         (------*------)
HSL-51      15    10.493    24.011                     (--------*--------)
                                        --------+---------+---------+-------
POOLED STDEV =     6.910                       4.0       8.0      12.0
```

	z	$z_{0.05}$
FRS vs. SEA:	-5.61971	1.645
LANT vs. PAC:	1.34907	1.645
LANT-Sea vs. PAC-Sea:	0.941623	1.645

MAINTENANCE MAN-HOUR/MAINTENANCE ACTION
(Efficiency)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	4.3518	1.0981			
FRS	48	3.4571	0.5077			
SEA	183	4.5864	1.0912			
LANT	120	4.578	1.297			
PAC	111	4.1070	0.7648			
LANT-Sea	96	4.873	1.258			
PAC-Sea	87	4.2706	0.7604			
HSL-40	24	3.400	0.594	-6.75	41	1.645
HSL-41	24	3.5142	0.4093	-7.58	66	1.645
HSL-42	24	6.492	1.133	8.84	27	1.703
HSL-43	24	4.392	0.702	0.25	35	1.645
HSL-44	24	4.523	0.722	1.04	35	1.645
HSL-45	24	4.631	0.502	2.22	50	1.645
HSL-46	24	4.613	0.707	1.62	35	1.645
HSL-48	24	3.863	0.490	-3.96	51	1.645
HSL-49	24	3.630	0.625	-4.93	39	1.645
HSL-51	15	4.525	0.815	0.78	17	1.740

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	171.460	19.051	39.76	0.000	2.41
ERROR	221	105.885	0.479			
TOTAL	230	277.345				

```
                                   INDIVIDUAL 95 PCT CI'S FOR MEAN
                                   BASED ON POOLED STDEV
LEVEL       N      MEAN    STDEV  ---------+---------+---------+-------
HSL-40     24    3.4000   0.5937  (--*--)
HSL-41     24    3.5142   0.4093   (--*--)
HSL-42     24    6.4921   1.1326                                (--*--)
HSL-43     24    4.3921   0.7023            (--*--)
HSL-44     24    4.5225   0.7222             (--*--)
HSL-45     24    4.6308   0.5025               (-*--)
HSL-46     24    4.6129   0.7067              (--*--)
HSL-48     24    3.8633   0.4899       (--*-)
HSL-49     24    3.6296   0.6245     (-*--)
HSL-51     15    4.5253   0.8149             (--*---)
                                  ---------+---------+---------+-------
POOLED STDEV =   0.6922                   4.0       5.0       6.0
```

	z	$z_{0.05}$
FRS vs. SEA:	-10.3624	1.645
LANT vs. PAC:	3.39227	1.645
LANT-Sea vs. PAC-Sea:	3.95805	1.645

CANNIBALIZATION MAN-HOUR PERCENTAGE
(Efficiency)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	1.8776	1.3220			
FRS	48	3.349	1.148			
SEA	183	1.4916	1.0712			
LANT	120	1.557	1.173			
PAC	111	2.224	1.390			
LANT-Sea	96	1.1441	0.8382			
PAC-Sea	87	1.875	1.170			
HSL-40	24	3.210	0.810	7.13	37	1.645
HSL-41	24	3.489	1.412	5.35	27	1.703
HSL-42	24	0.765	0.577	-7.60	53	1.645
HSL-43	24	2.120	0.930	1.16	33	1.645
HSL-44	24	1.006	0.819	-4.63	36	1.645
HSL-45	24	1.185	0.946	-3.27	33	1.645
HSL-46	24	1.117	0.504	-5.65	64	1.645
HSL-48	24	1.689	1.079	-0.80	30	1.645
HSL-49	24	2.068	1.175	0.74	29	1.699
HSL-51	15	2.280	1.446	1.05	15	1.753

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	183.793	20.421	20.69	0.000	2.41
ERROR	221	218.163	0.987			
TOTAL	230	401.956				

```
                                          INDIVIDUAL 95 PCT CI'S FOR MEAN
                                          BASED ON POOLED STDEV
LEVEL        N      MEAN      STDEV   -------+---------+---------+--------
HSL-40      24    3.2096     0.8099                          (---*---)
HSL-41      24    3.4887     1.4122                             (---*---)
HSL-42      24    0.7650     0.5771    (---*---)
HSL-43      24    2.1196     0.9296                (---*---)
HSL-44      24    1.0058     0.8191      (---*---)
HSL-45      24    1.1850     0.9461        (---*---)
HSL-46      24    1.1167     0.5044       (---*---)
HSL-48      24    1.6888     1.0787             (---*---)
HSL-49      24    2.0675     1.1755                (---*---)
HSL-51      15    2.2800     1.4456                 (----*----)
                                      -------+---------+---------+--------
POOLED STDEV =    0.9936                    1.0       2.0       3.0
```

	z	$z_{0.05}$
FRS vs. SEA:	10.1181	1.645
LANT vs. PAC:	-3.92394	1.645
LANT-Sea vs. PAC-Sea:	-4.81460	1.645

CANNIBALIZATION ITEMS PERCENTAGE
(Efficiency)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	1.6920	0.8966			
FRS	48	2.439	0.852			
SEA	183	1.4961	0.8016			
LANT	120	1.5753	0.7559			
PAC	111	1.8183	1.0157			
LANT-Sea	96	1.3800	0.6435			
PAC-Sea	87	1.624	0.933			
HSL-40	24	2.356	0.671	4.45	32	1.645
HSL-41	24	2.522	1.009	3.87	26	1.706
HSL-42	24	1.241	0.632	-3.18	33	1.645
HSL-43	24	2.089	0.882	2.10	28	1.701
HSL-44	24	1.187	0.719	-3.19	30	1.645
HSL-45	24	0.989	0.622	-5.02	33	1.645
HSL-46	24	1.586	0.637	-0.74	33	1.645
HSL-48	24	1.506	0.519	-1.54	39	1.645
HSL-49	24	1.568	0.838	-0.68	28	1.701
HSL-51	15	1.987	1.036	1.08	15	1.753

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	56.531	6.281	10.82	0.000	2.41
ERROR	221	128.349	0.581			
TOTAL	230	184.880				

```
                                      INDIVIDUAL 95 PCT CI'S FOR MEAN
                                      BASED ON POOLED STDEV
LEVEL       N      MEAN     STDEV    ---------+---------+---------+-------
HSL-40     24    2.3563    0.6712                          (----*----)
HSL-41     24    2.5217    1.0092                             (----*----)
HSL-42     24    1.2408    0.6315         (----*----)
HSL-43     24    2.0892    0.8822                      (----*----)
HSL-44     24    1.1875    0.7189        (----*----)
HSL-45     24    0.9887    0.6223    (----*-----)
HSL-46     24    1.5858    0.6370              (----*-----)
HSL-48     24    1.5058    0.5189             (----*----)
HSL-49     24    1.5683    0.8376              (----*----)
HSL-51     15    1.9867    1.0362                   (-----*------)
                                     ---------+---------+---------+-------
POOLED STDEV =   0.7621                      1.20      1.80      2.40
```

	z	$z_{0.05}$
FRS vs. SEA:	6.90691	1.645
LANT vs. PAC:	-2.04999	1.645
LANT-Sea vs. PAC-Sea:	-2.04082	1.645

CANNIBALIZATION ITEMS PER 100 FLIGHT HOURS
(Efficiency)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	5.917	4.742			
FRS	48	11.211	4.285			
SEA	183	4.528	3.788			
LANT	120	6.029	4.864			
PAC	111	5.795	4.626			
LANT-Sea	96	4.584	3.972			
PAC-Sea	87	4.466	3.595			
HSL-40	24	11.808	3.699	7.21	31	1.645
HSL-41	24	10.613	4.806	4.56	27	1.703
HSL-42	24	3.201	2.328	-4.78	46	1.645
HSL-43	24	5.428	1.885	-0.99	60	1.645
HSL-44	24	5.84	5.56	-0.07	26	1.706
HSL-45	24	1.700	1.204	-10.62	124	1.645
HSL-46	24	5.695	4.469	-0.23	28	1.701
HSL-48	24	3.605	1.726	-4.91	68	1.645
HSL-49	24	3.512	2.441	-4.09	43	1.645
HSL-51	15	8.88	4.93	2.26	15	1.753

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	2372.1	263.6	20.80	0.000	2.41
ERROR	221	2800.2	12.7			
TOTAL	230	5172.3				

```
                                            INDIVIDUAL 95 PCT CI'S FOR MEAN
                                            BASED ON POOLED STDEV
LEVEL        N     MEAN        STDEV   ----------+---------+---------+------
HSL-40      24    11.808       3.699                             (---*--)
HSL-41      24    10.613       4.806                          (---*--)
HSL-42      24     3.201       2.328        (---*---)
HSL-43      24     5.428       1.885              (---*--)
HSL-44      24     5.837       5.556               (---*--)
HSL-45      24     1.700       1.204     (--*---)
HSL-46      24     5.695       4.469               (--*---)
HSL-48      24     3.605       1.726         (---*---)
HSL-49      24     3.512       2.441         (---*--)
HSL-51      15     8.881       4.925                        (---*----)
                                       ----------+---------+---------+------
POOLED STDEV =     3.560                        4.0       8.0      12.0
```

	z	$z_{0.05}$
FRS vs. SEA:	9.84269	1.645
LANT vs. PAC:	0.374485	1.645
LANT-Sea vs. PAC-Sea:	0.211221	1.645

MEAN TIME BETWEEN FAILURES
(Quality)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	0.3867	0.1857			
FRS	48	0.22562	0.04568			
SEA	183	0.4290	0.1854			
LANT	120	0.3522	0.1608			
PAC	111	0.4241	0.2035			
LANT-Sea	96	0.3889	0.1587			
PAC-Sea	87	0.4733	0.2029			
HSL-40	24	0.20562	0.04163	-12.17	151	1.645
HSL-41	24	0.24563	0.04119	-9.52	153	1.645
HSL-42	24	0.4349	0.1484	1.48	31	1.645
HSL-43	24	0.4047	0.1591	0.52	29	1.699
HSL-44	24	0.3008	0.1568	-2.51	30	1.645
HSL-45	24	0.6319	0.1495	7.46	30	1.645
HSL-46	24	0.3695	0.1624	-0.49	29	1.699
HSL-48	24	0.4502	0.1281	2.20	33	1.645
HSL-49	24	0.5175	0.1828	3.33	28	1.701
HSL-51	15	0.2585	0.1252	-3.71	18	1.734

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	3.7088	0.4121	21.59	0.000	2.41
ERROR	221	4.2188	0.0191			
TOTAL	230	7.9275				

```
                                         INDIVIDUAL 95 PCT CI'S FOR MEAN
                                         BASED ON POOLED STDEV
LEVEL        N      MEAN      STDEV      ---------+---------+---------+------
HSL-40      24    0.2056     0.0416      (---*--)
HSL-41      24    0.2456     0.0412         (--*---)
HSL-42      24    0.4349     0.1484                     (---*---)
HSL-43      24    0.4047     0.1591                   (---*---)
HSL-44      24    0.3008     0.1568            (---*---)
HSL-45      24    0.6319     0.1495                                  (---*---)
HSL-46      24    0.3695     0.1624                 (---*--)
HSL-48      24    0.4502     0.1281                      (---*---)
HSL-49      24    0.5175     0.1828                           (---*--)
HSL-51      15    0.2585     0.1252         (---*----)
                                         ---------+---------+---------+------
POOLED STDEV =    0.1382                          0.30      0.45      0.60
```

	z	$z_{0.05}$
FRS vs. SEA:	-13.3707	1.645
LANT vs. PAC:	-2.96169	1.645
LANT-Sea vs. PAC-Sea:	-3.11291	1.645

CORROSION CONTROL RATIO
(Quality)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	26.49	16.02			
FRS	48	18.58	8.60			
SEA	183	28.56	16.86			
LANT	120	37.42	12.93			
PAC	111	14.669	9.179			
LANT-Sea	96	40.38	12.76			
PAC-Sea	87	15.52	9.68			
HSL-40	24	25.584	3.038	-0.74	189	1.645
HSL-41	24	11.57	6.29	-8.98	61	1.645
HSL-42	24	55.53	7.29	15.93	50	1.645
HSL-43	24	26.70	8.68	0.10	41	1.645
HSL-44	24	38.53	9.16	5.61	39	1.645
HSL-45	24	9.446	4.328	-12.39	112	1.645
HSL-46	24	41.59	5.92	9.41	67	1.645
HSL-48	24	25.87	6.02	-0.38	65	1.645
HSL-49	24	9.502	3.666	-13.14	146	1.645
HSL-51	15	17.00	7.59	-4.26	23	1.714

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	49806.9	5534.1	132.99	0.000	2.41
ERROR	221	9196.1	41.6			
TOTAL	230	59003.1				

```
                                        INDIVIDUAL 95 PCT CI'S FOR MEAN
                                        BASED ON POOLED STDEV
LEVEL        N      MEAN      STDEV     ------+---------+---------+---------+
HSL-40      24    25.584      3.038                (-*-)
HSL-41      24    11.571      6.289       (-*)
HSL-42      24    55.530      7.290                                   (-*-)
HSL-43      24    26.698      8.677                 (-*-)
HSL-44      24    38.525      9.163                         (-*)
HSL-45      24     9.446      4.328      (*-)
HSL-46      24    41.587      5.924                           (-*)
HSL-48      24    25.872      6.024                 (*-)
HSL-49      24     9.502      3.666      (*-)
HSL-51      15    17.002      7.595          (-*--)
                                        ------+---------+---------+---------+
POOLED STDEV =     6.451                     15        30        45        60
```

	z	$z_{0.05}$
FRS vs. SEA:	-5.67564	1.645
LANT vs. PAC:	15.5096	1.645
LANT-Sea vs. PAC-Sea:	14.9221	1.645

CORROSION CONTROL TO FLIGHT HOUR RATIO
(Quality)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	5.059	9.573			
FRS	48	3.081	1.791			
SEA	183	5.578	10.662			
LANT	120	7.97	12.50			
PAC	111	1.908	1.841			
LANT-Sea	96	8.87	13.83			
PAC-Sea	87	1.947	1.987			
HSL-40	24	4.395	1.235	-0.98	246	1.645
HSL-41	24	1.766	1.194	-4.88	248	1.645
HSL-42	24	9.79	6.12	3.38	35	1.645
HSL-43	24	3.277	1.768	0.015	195	1.645
HSL-44	24	15.09	23.83	0.052	23	1.714
HSL-45	24	0.7308	0.3774	-6.82	236	1.645
HSL-46	24	8.18	9.89	1.48	27	1.703
HSL-48	24	2.414	1.097	-3.96	251	1.645
HSL-49	24	0.7206	0.3104	-6.85	234	1.645
HSL-51	15	3.725	2.682	-1.43	44	1.645

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	4629.2	514.4	6.91	0.000	2.41
ERROR	221	16446.5	74.4			
TOTAL	230	21075.7				

```
                                   INDIVIDUAL 95 PCT CI'S FOR MEAN
                                   BASED ON POOLED STDEV
LEVEL        N      MEAN    STDEV  -----+---------+---------+---------+-
HSL-40      24     4.395    1.235         (----*-----)
HSL-41      24     1.766    1.194    (-----*-----)
HSL-42      24     9.791    6.120                 (----*-----)
HSL-43      24     3.277    1.768       (----*-----)
HSL-44      24    15.089   23.832                         (-----*-----)
HSL-45      24     0.731    0.377  (-----*-----)
HSL-46      24     8.183    9.886              (-----*----)
HSL-48      24     2.414    1.097     (-----*-----)
HSL-49      24     0.721    0.310  (-----*-----)
HSL-51      15     3.725    2.682      (------*-------)
                                   -----+---------+---------+---------+-
POOLED STDEV =     8.627                0.0       6.0      12.0      18.0
```

	z	$z_{0.05}$
FRS vs. SEA:	-3.01105	1.645
LANT vs. PAC:	5.25720	1.645
LANT-Sea vs. PAC-Sea:	4.85075	1.645

UNSCHEDULED MAN-HOUR RATIO
(Quality)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	94.808	3.216			
FRS	48	91.719	3.350			
SEA	183	95.618	2.644			
LANT	120	94.549	3.402			
PAC	111	95.088	2.991			
LANT-Sea	96	95.495	2.660			
PAC-Sea	87	95.753	2.636			
HSL-40	24	90.763	3.462	-5.48	27	1.703
HSL-41	24	92.675	3.007	-3.29	28	1.701
HSL-42	24	96.074	2.815	2.07	29	1.699
HSL-43	24	95.079	2.210	0.54	34	1.645
HSL-44	24	96.228	2.770	2.35	29	1.699
HSL-45	24	97.403	2.106	5.42	35	1.645
HSL-46	24	94.556	2.008	-0.55	36	1.645
HSL-48	24	95.124	2.760	0.52	29	1.699
HSL-49	24	95.200	2.583	0.69	30	1.645
HSL-51	15	95.079	3.156	0.32	15	1.753

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	760.77	84.53	11.55	0.000	2.41
ERROR	221	1617.45	7.32			
TOTAL	230	2378.23				

```
                                    INDIVIDUAL 95 PCT CI'S FOR MEAN
                                    BASED ON POOLED STDEV
LEVEL        N      MEAN     STDEV  --+---------+---------+---------+----
HSL-40      24    90.763     3.462   (---*---)
HSL-41      24    92.675     3.007          (----*---)
HSL-42      24    96.074     2.815                        (---*----)
HSL-43      24    95.079     2.210                    (---*----)
HSL-44      24    96.228     2.770                         (---*---)
HSL-45      24    97.403     2.106                             (----*---)
HSL-46      24    94.556     2.008                  (---*----)
HSL-48      24    95.124     2.760                    (---*----)
HSL-49      24    95.200     2.583                    (----*---)
HSL-51      15    95.079     3.156                   (----*-----)
                                    --+---------+---------+---------+----
POOLED STDEV =   2.705              90.0      92.5      95.0      97.5
```

	z	$z_{0.05}$
FRS vs. SEA:	-7.47602	1.645
LANT vs. PAC:	-1.28067	1.645
LANT-Sea vs. PAC-Sea:	-0.658741	1.645

TOTAL DIRECT MAN-HOUR/FLIGHT HOUR RATIO
(Productivity)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	15.90	19.37			
FRS	48	15.982	4.409			
SEA	183	15.88	21.66			
LANT	120	19.50	25.66			
PAC	111	12.002	6.566			
LANT-Sea	96	20.07	28.57			
PAC-Sea	87	11.253	7.067			
HSL-40	24	17.25	5.17	0.81	114	1.645
HSL-41	24	14.717	3.103	-0.83	222	1.645
HSL-42	24	17.23	9.48	0.57	46	1.645
HSL-43	24	11.896	3.460	-2.75	202	1.645
HSL-44	24	34.3	49.3	1.82	23	1.714
HSL-45	24	7.720	1.949	-6.13	252	1.645
HSL-46	24	19.46	22.39	0.75	26	1.706
HSL-48	24	9.273	2.988	-4.69	227	1.645
HSL-49	24	7.592	2.317	-6.11	250	1.645
HSL-51	15	21.74	10.45	1.96	20	1.725

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	13772	1530	4.66	0.000	2.41
ERROR	221	72543	328			
TOTAL	230	86315				

```
                                     INDIVIDUAL 95 PCT CI'S FOR MEAN
                                     BASED ON POOLED STDEV
LEVEL       N      MEAN     STDEV   ----------+---------+---------+------
HSL-40     24     17.25      5.17           (-----*-----)
HSL-41     24     14.72      3.10         (-----*-----)
HSL-42     24     17.23      9.48           (-----*-----)
HSL-43     24     11.90      3.46       (-----*-----)
HSL-44     24     34.31     49.30                       (-----*-----)
HSL-45     24      7.72      1.95   (-----*------)
HSL-46     24     19.46     22.39             (-----*-----)
HSL-48     24      9.27      2.99     (-----*-----)
HSL-49     24      7.59      2.32   (-----*-----)
HSL-51     15     21.74     10.45             (-------*-------)
                                    ----------+---------+---------+------
POOLED STDEV =    18.12                      12        24        36
```

	z	$z_{0.05}$
FRS vs. SEA:	0.0601154	1.645
LANT vs. PAC:	3.09566	1.645
LANT-Sea vs. PAC-Sea:	2.92595	1.645

SCHEDULED DIRECT MAN-HOUR/FLIGHT HOUR RATIO
(Productivity)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	10.80	16.16			
FRS	48	9.340	3.097			
SEA	183	11.18	18.07			
LANT	120	14.73	21.40			
PAC	111	6.545	3.881			
LANT-Sea	96	15.66	23.81			
PAC-Sea	87	6.233	4.227			
HSL-40	24	11.005	3.205	0.17	179	1.645
HSL-41	24	7.674	1.882	-2.76	251	1.645
HSL-42	24	13.92	7.67	1.65	48	1.645
HSL-43	24	6.548	1.736	-3.79	252	1.645
HSL-44	24	27.28	41.46	1.93	23	1.714
HSL-45	24	4.185	1.157	-6.07	247	1.645
HSL-46	24	15.38	17.89	1.21	27	1.703
HSL-48	24	6.070	2.023	-4.15	248	1.645
HSL-49	24	4.326	1.403	-5.88	251	1.645
HSL-51	15	12.06	7.03	0.60	25	1.708

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	10543	1171	5.23	0.000	2.41
ERROR	221	49487	224			
TOTAL	230	60030				

```
                                        INDIVIDUAL 95 PCT CI'S FOR MEAN
                                        BASED ON POOLED STDEV
LEVEL       N      MEAN     STDEV   --+---------+---------+---------+----
HSL-40     24     11.01      3.21              (-----*-----)
HSL-41     24      7.67      1.88           (-----*-----)
HSL-42     24     13.92      7.67                 (-----*-----)
HSL-43     24      6.55      1.74          (-----*-----)
HSL-44     24     27.28     41.46                                (-----*-----)
HSL-45     24      4.18      1.16       (-----*-----)
HSL-46     24     15.38     17.89                  (-----*-----)
HSL-48     24      6.07      2.02         (-----*-----)
HSL-49     24      4.33      1.40       (-----*-----)
HSL-51     15     12.06      7.03             (-------*-------)
                                    --+---------+---------+---------+----
POOLED STDEV =    14.96                0        10        20        30
```

	z	$z_{0.05}$
FRS vs. SEA:	-1.30683	1.645
LANT vs. PAC:	4.11833	1.645
LANT-Sea vs. PAC-Sea:	3.81538	1.645

UNSCHEDULED DIRECT MAN-HOUR/FLIGHT HOUR RATIO
(Productivity)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	5.101	4.010			
FRS	48	6.642	1.983			
SEA	183	4.696	4.303			
LANT	120	4.772	4.751			
PAC	111	5.456	2.993			
LANT-Sea	96	4.405	5.131			
PAC-Sea	87	5.018	3.148			
HSL-40	24	6.242	2.291	2.13	39	1.645
HSL-41	24	7.042	1.566	4.68	62	1.645
HSL-42	24	3.516	2.197	-3.04	41	1.645
HSL-43	24	5.343	2.134	0.48	42	1.645
HSL-44	24	7.03	8.36	1.12	24	1.711
HSL-45	24	3.534	1.019	-4.66	124	1.645
HSL-46	24	4.079	4.820	-1.00	26	1.706
HSL-48	24	3.203	1.064	-5.55	115	1.645
HSL-49	24	3.266	1.109	-5.28	108	1.645
HSL-51	15	9.68	4.15	4.15	15	1.753

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	838.0	93.1	7.21	0.000	2.41
ERROR	221	2853.5	12.9			
TOTAL	230	3691.5				

```
                                         INDIVIDUAL 95 PCT CI'S FOR MEAN
                                         BASED ON POOLED STDEV
LEVEL        N      MEAN      STDEV      -----+---------+---------+---------+-
HSL-40      24     6.242      2.291                 (----*----)
HSL-41      24     7.042      1.566                    (---*----)
HSL-42      24     3.516      2.197        (----*----)
HSL-43      24     5.343      2.134              (----*----)
HSL-44      24     7.031      8.360                    (---*----)
HSL-45      24     3.534      1.019        (----*----)
HSL-46      24     4.079      4.820          (----*---)
HSL-48      24     3.203      1.064       (----*---)
HSL-49      24     3.266      1.109       (----*----)
HSL-51      15     9.677      4.146                           (-----*-----)
                                         -----+---------+---------+---------+-
POOLED STDEV =     3.593                     3.0       6.0       9.0      12.0
```

	z	$z_{0.05}$
FRS vs. SEA:	4.54692	1.645
LANT vs. PAC:	-1.31772	1.645
LANT-Sea vs. PAC-Sea:	-0.984362	1.645

TOTAL FLIGHT HOUR/TOTAL MAN-HOUR RATIO
(Productivity)

	N	MEAN	STDEV	t	df	$t_{0.05}$
ALL SQDNS	231	0.09125	0.04301			
FRS	48	0.06631	0.01507			
SEA	183	0.09779	0.04552			
LANT	120	0.07957	0.03626			
PAC	111	0.10387	0.04621			
LANT-Sea	96	0.08401	0.03867			
PAC-Sea	87	0.11299	0.04782			
HSL-40	24	0.06182	0.01467	-7.14	76	1.645
HSL-41	24	0.07080	0.01437	-5.02	78	1.645
HSL-42	24	0.06971	0.02897	-3.29	34	1.645
HSL-43	24	0.09118	0.02851	-0.01	34	1.645
HSL-44	24	0.06749	0.03570	-3.04	30	1.645
HSL-45	24	0.13737	0.03332	6.26	31	1.645
HSL-46	24	0.08101	0.03377	-1.37	31	1.645
HSL-48	24	0.11782	0.03496	3.46	30	1.645
HSL-49	24	0.14419	0.04509	5.50	27	1.703
HSL-51	15	0.05897	0.03029	-3.88	17	1.740

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	$F_{0.05}$
FACTOR	9	0.208913	0.023213	23.70	0.000	2.41
ERROR	221	0.216496	0.000980			
TOTAL	230	0.425409				

```
                                          INDIVIDUAL 95 PCT CI'S FOR MEAN
                                          BASED ON POOLED STDEV
LEVEL       N      MEAN      STDEV     --------+---------+---------+--------
HSL-40     24   0.06182    0.01467       (---*--)
HSL-41     24   0.07080    0.01437          (--*---)
HSL-42     24   0.06971    0.02897         (---*---)
HSL-43     24   0.09118    0.02851               (---*---)
HSL-44     24   0.06749    0.03570         (--*---)
HSL-45     24   0.13737    0.03332                         (--*---)
HSL-46     24   0.08101    0.03377             (--*---)
HSL-48     24   0.11782    0.03496                       (---*--)
HSL-49     24   0.14419    0.04509                           (--*---)
HSL-51     15   0.05897    0.03029     (----*---)
                                       --------+---------+---------+--------
POOLED STDEV =  0.03130                      0.070     0.105     0.140
```

	z	$z_{0.05}$
FRS vs. SEA:	-7.85662	1.645
LANT vs. PAC:	-4.42278	1.645
LANT-Sea vs. PAC-Sea:	-4.48022	1.645

APPENDIX D

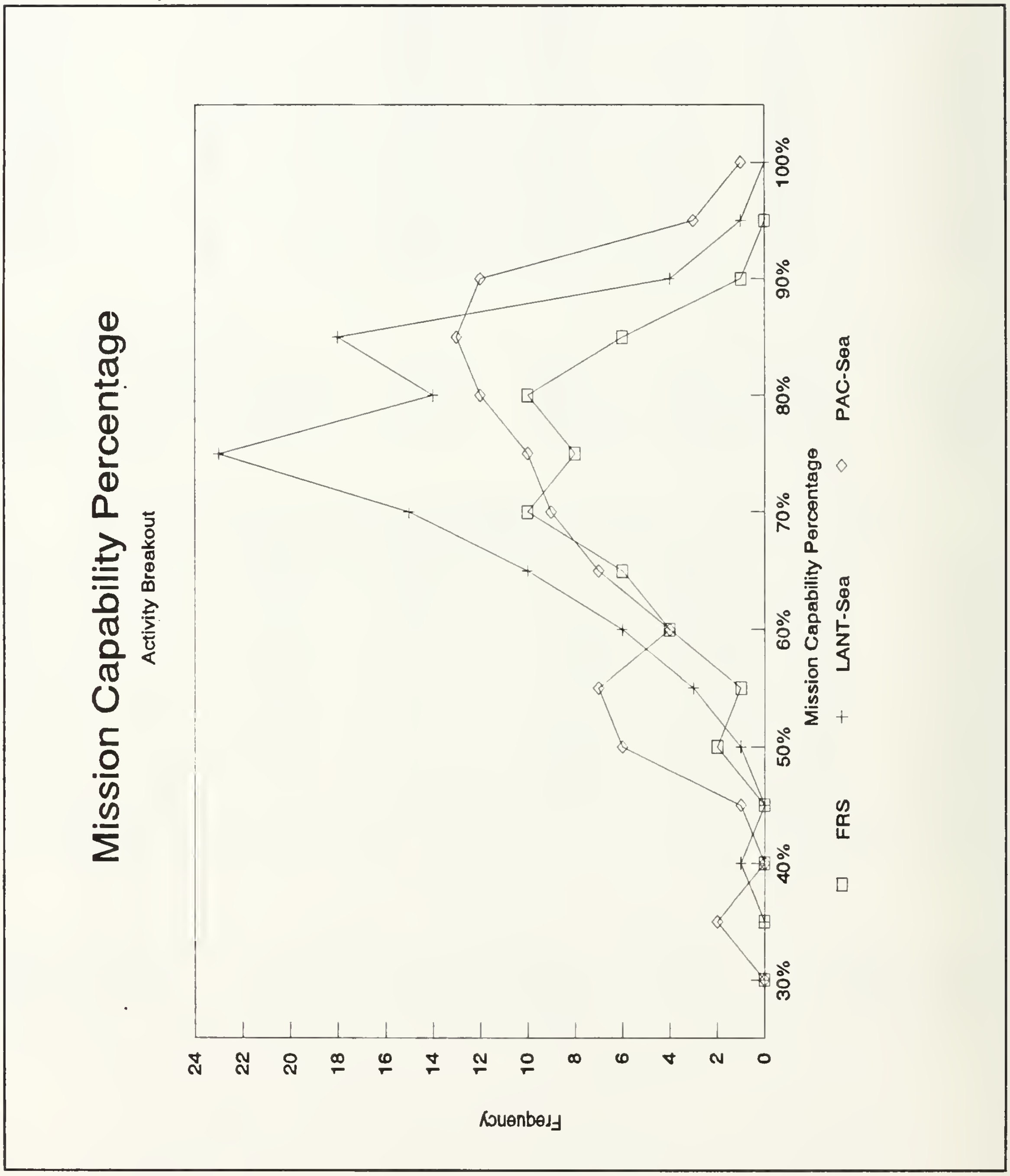
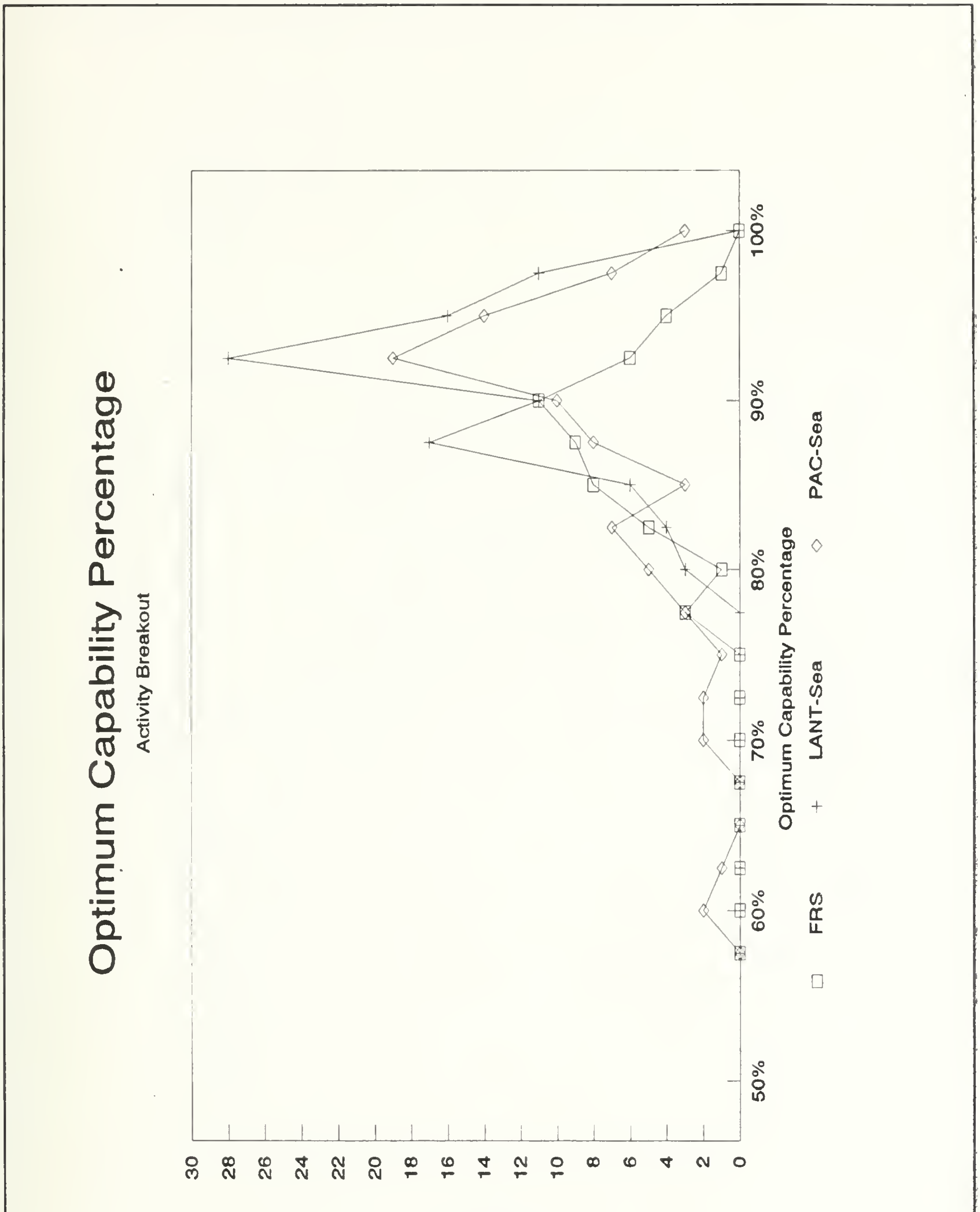


Figure 61



Optimum Capability Percentage
Activity Breakout
Frequency
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
50%
60%
70%
80%
90%
100%
Optimum Capability Percentage
FRS
LANT-Sea
PAC-Sea

Figure 62

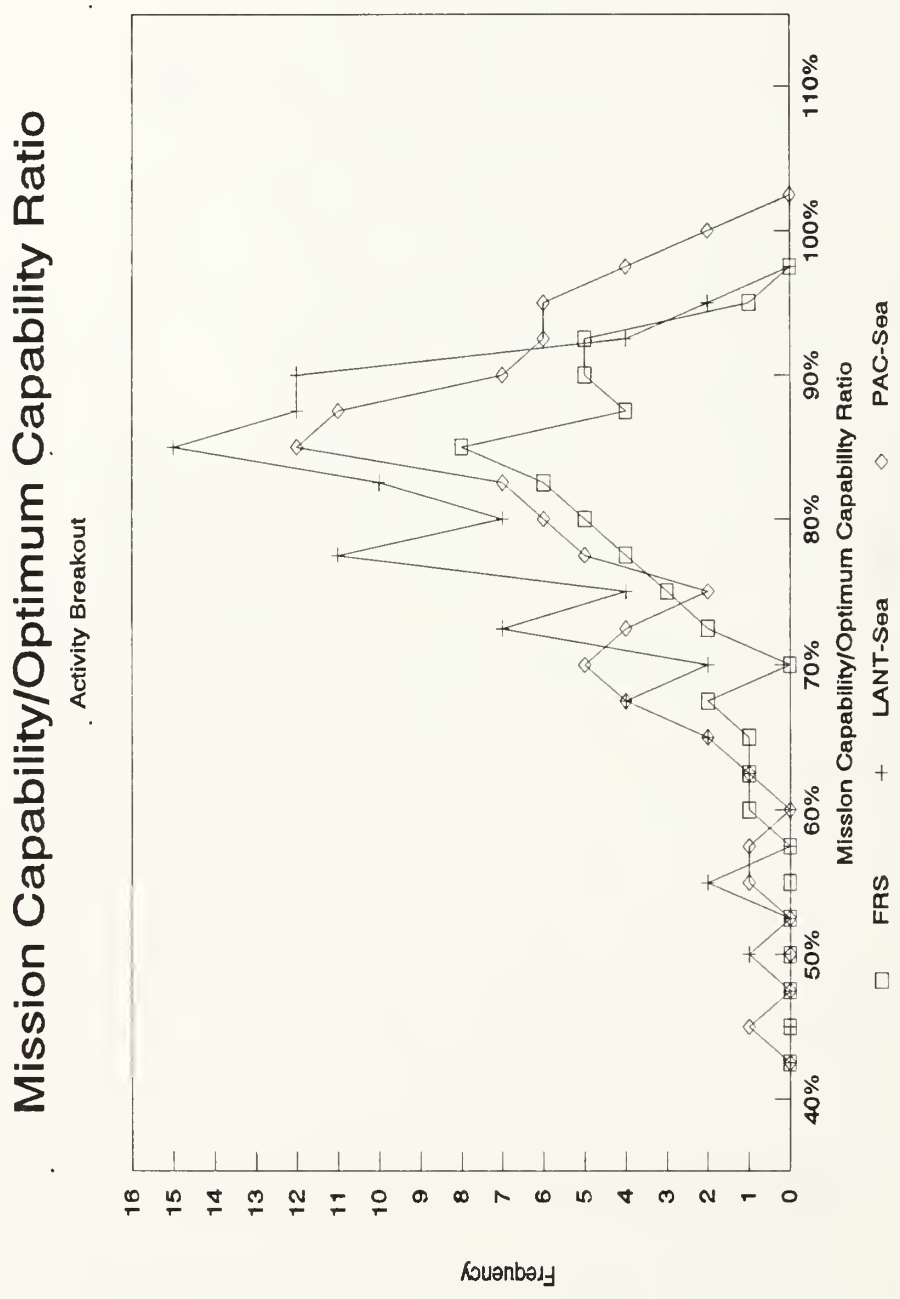
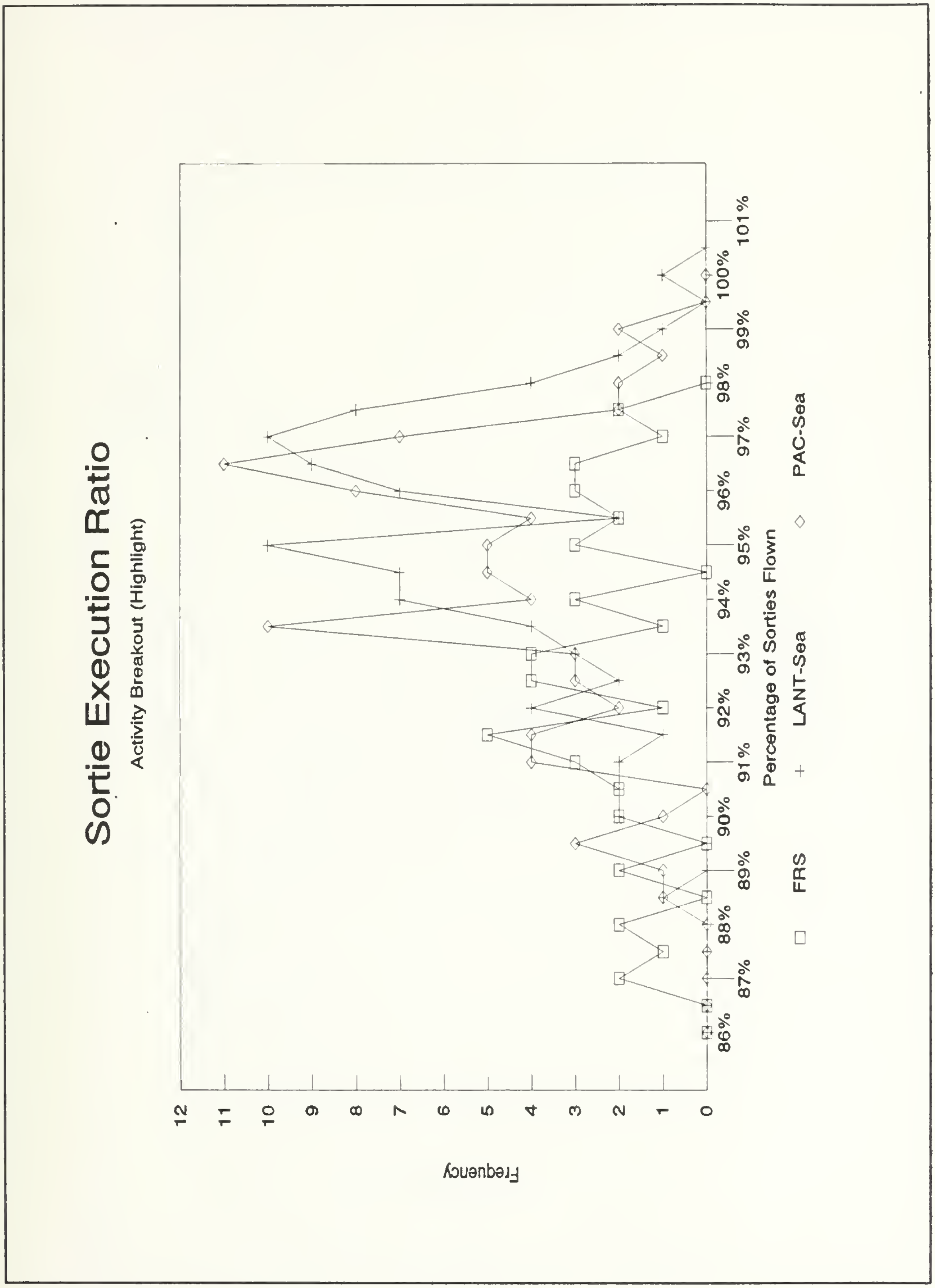

Mission Capability/Optimum Capability Ratio
Activity Breakout
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
40%
50%
60%
70%
80%
90%
100%
110%
Mission Capability/Optimum Capability Ratio
FRS
LANT-Sea
PAC-Sea

Figure 63.


Sortie Execution Ratio
Activity Breakout (Highlight)
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
86%
87%
88%
89%
90%
91%
92%
93%
94%
95%
96%
97%
98%
99%
100%
101%
Percentage of Sorties Flown
FRS
LANT-Sea
PAC-Sea
Figure 64

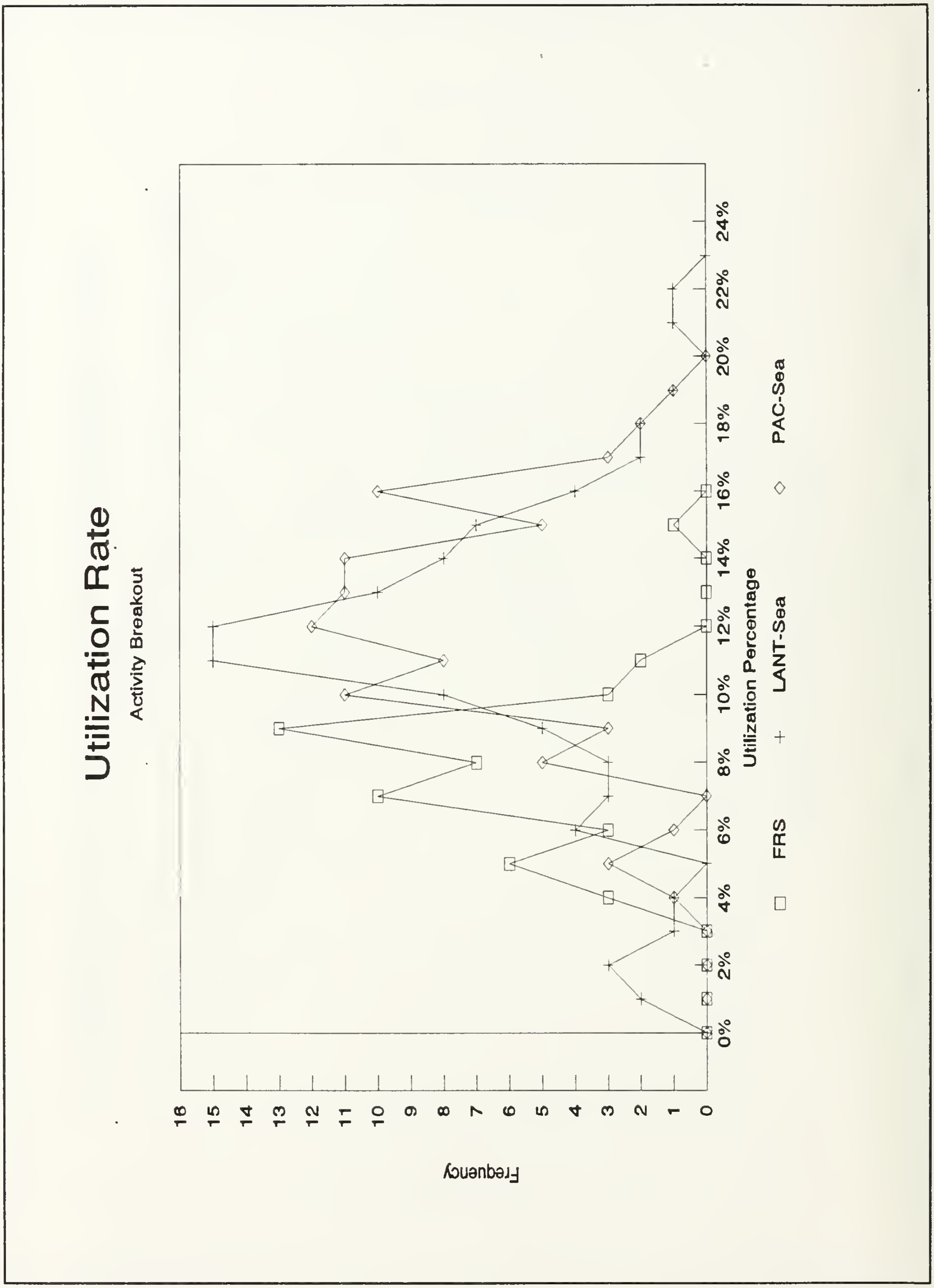

Utilization Rate
Activity Breakout
Frequency
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
0% 2% 4% 6% 8% 10% 12% 14% 16% 18% 20% 22% 24%
Utilization Percentage
FRS
LANT-Sea
PAC-Sea

Figure 65

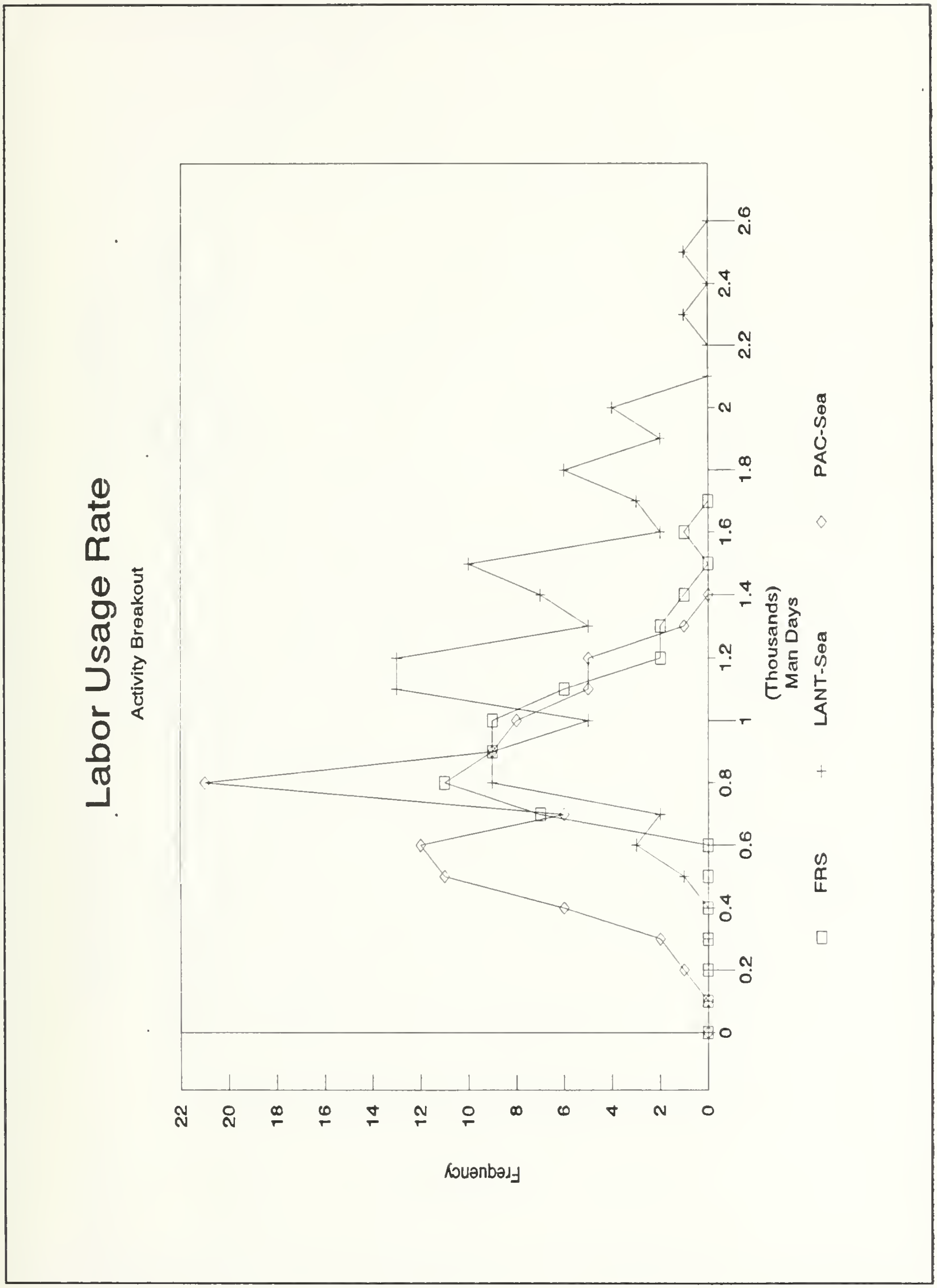
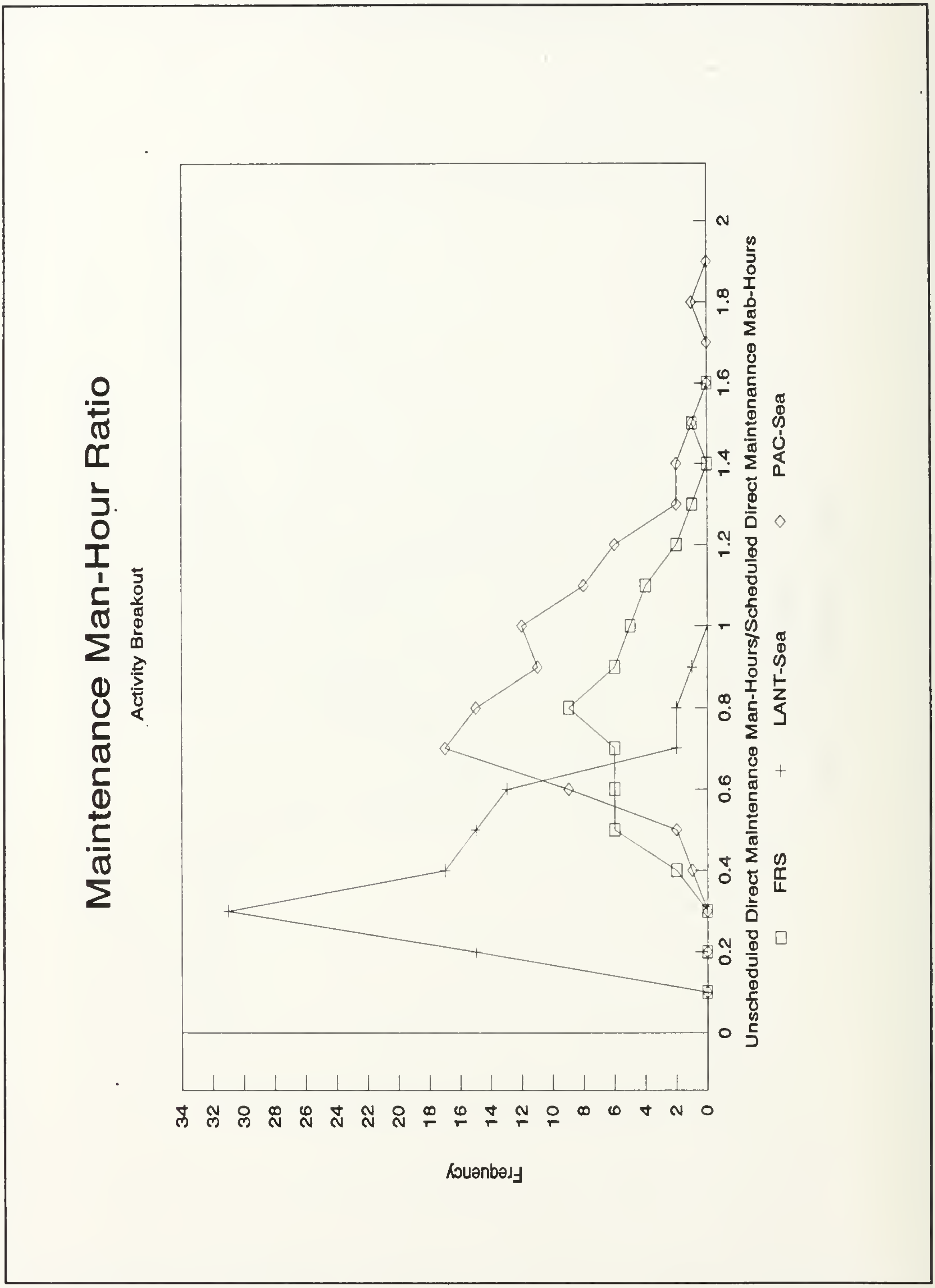
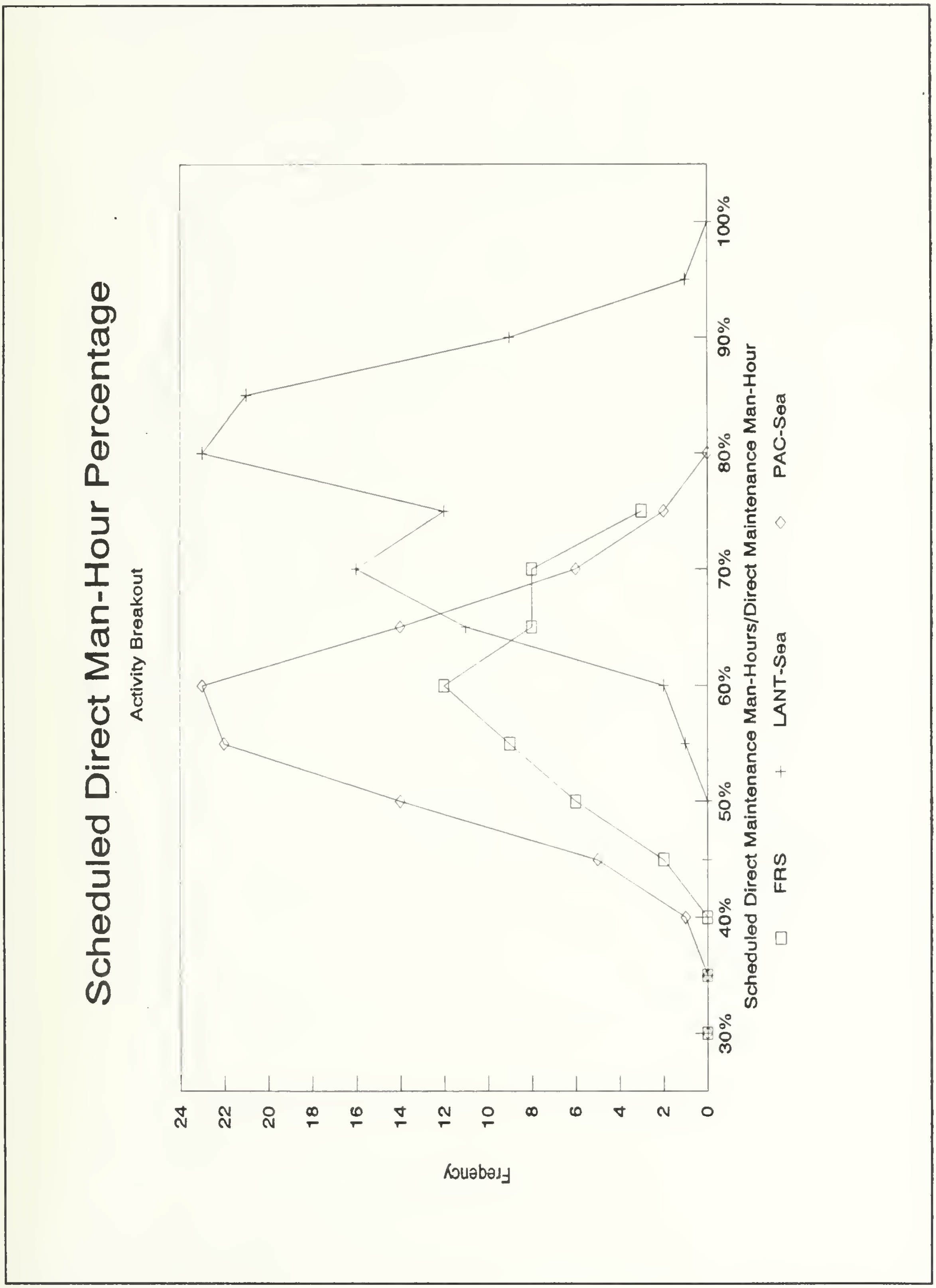
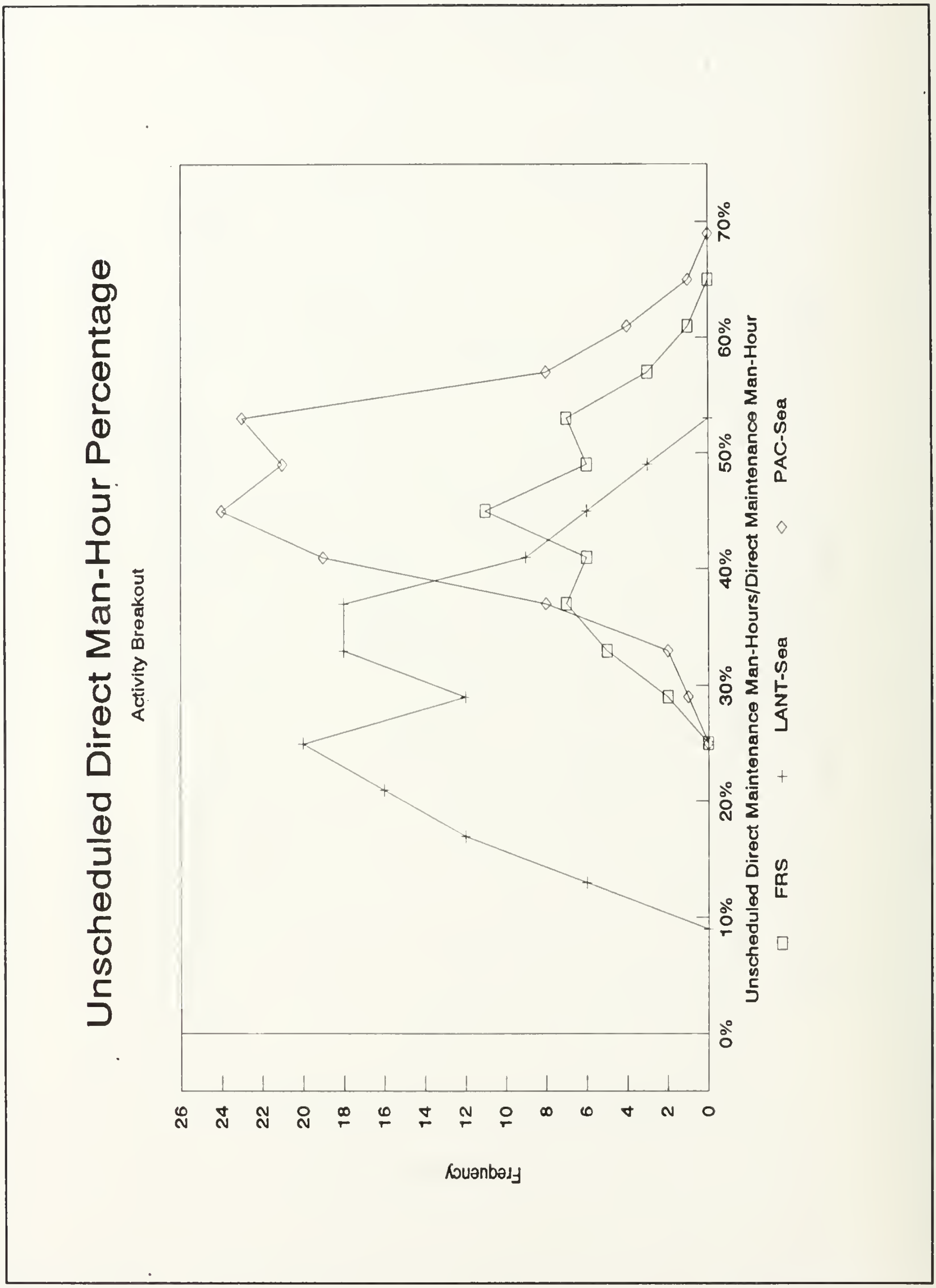

Labor Usage Rate
Activity Breakout
Frequency
0
2
4
6
8
10
12
14
16
18
20
22
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
(Thousands)
Man Days
FRS
LANT-Sea
PAC-Sea

Figure 66


Maintenance Man-Hour Ratio
Activity Breakout
Frequency
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Unscheduled Direct Maintenance Man-Hours/Scheduled Direct Maintenannce Mab-Hours
FRS
LANT-Sea
PAC-Sea
Figure 67


Scheduled Direct Man-Hour Percentage
Activity Breakout
Frequency
0
2
4
6
8
10
12
14
16
18
20
22
24
30%
40%
50%
60%
70%
80%
90%
100%
Scheduled Direct Maintenance Man-Hours/Direct Maintenance Man-Hour
FRS
LANT-Sea
PAC-Sea
Figure 68


Unscheduled Direct Man-Hour Percentage
Activity Breakout
Frequency
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
60%
70%
Unscheduled Direct Maintenance Man-Hours/Direct Maintenance Man-Hour
FRS
LANT-Sea
PAC-Sea
Figure 69

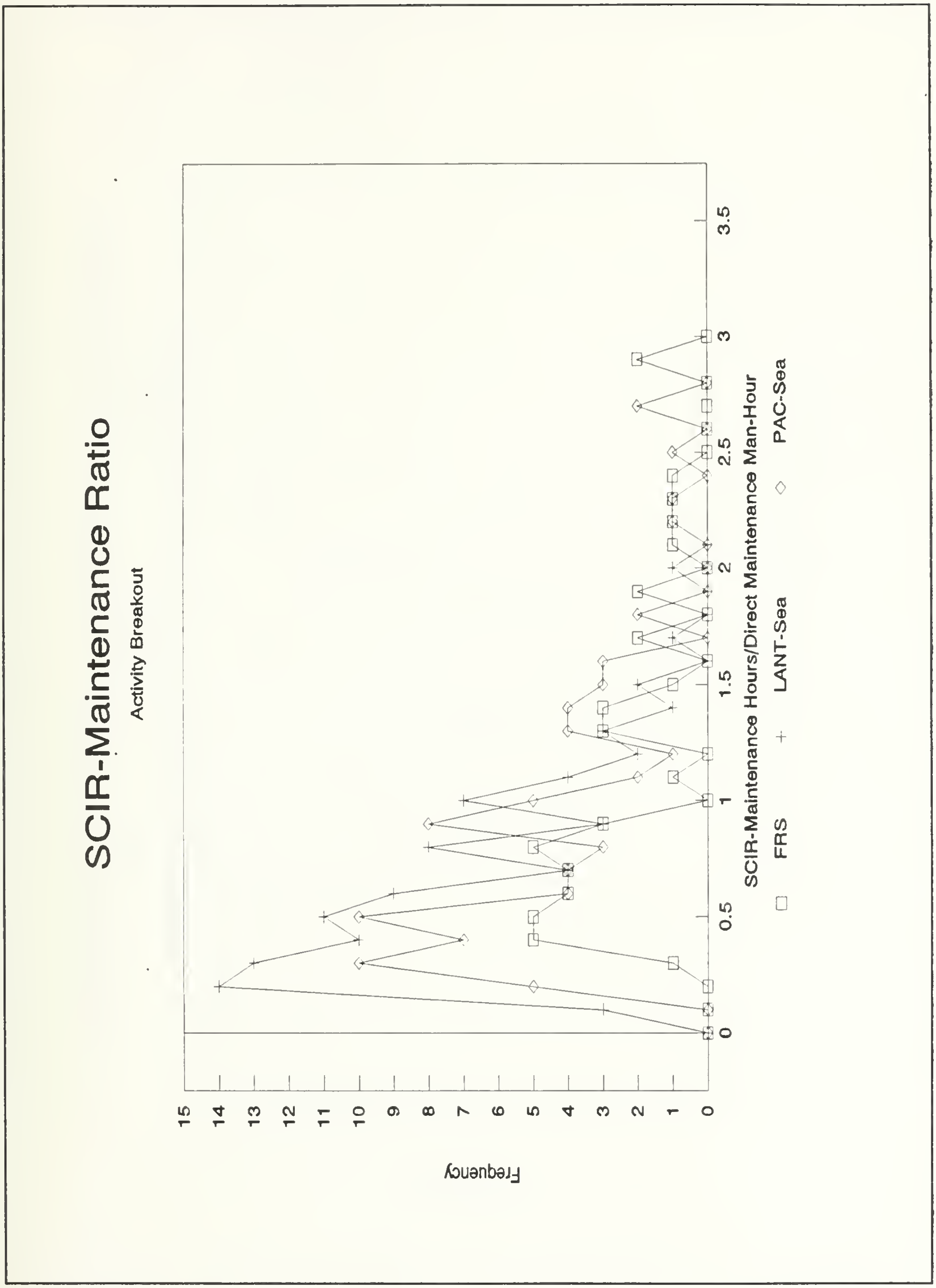

SCIR-Maintenance Ratio
Activity Breakout
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
0.5
1
1.5
2
2.5
3
3.5
SCIR-Maintenance Hours/Direct Maintenance Man-Hour
FRS
LANT-Sea
PAC-Sea

Figure 70

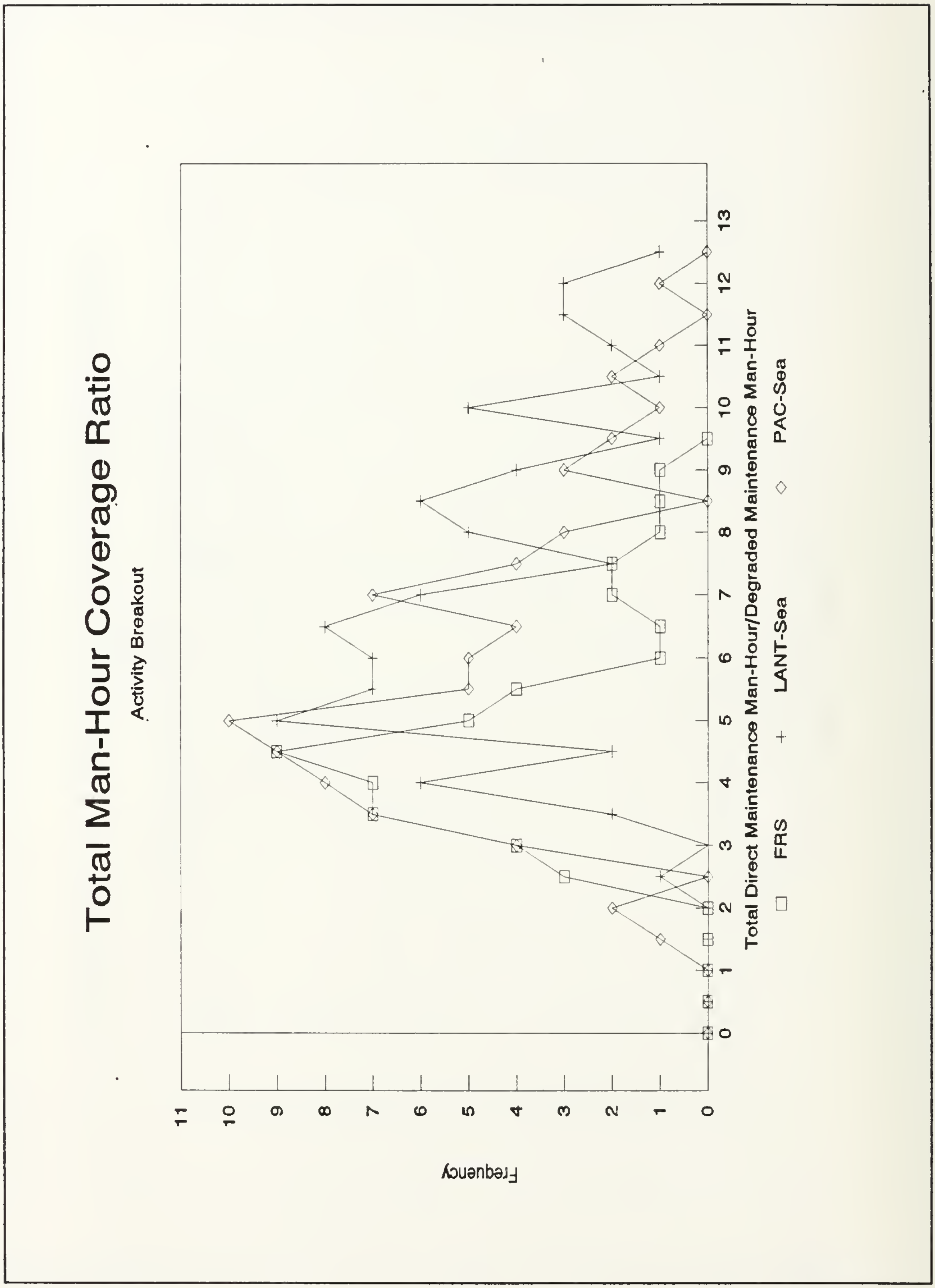

Total Man-Hour Coverage Ratio
Activity Breakout
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Total Direct Maintenance Man-Hour/Degraded Maintenance Man-Hour
FRS
LANT-Sea
PAC-Sea

Figure 71

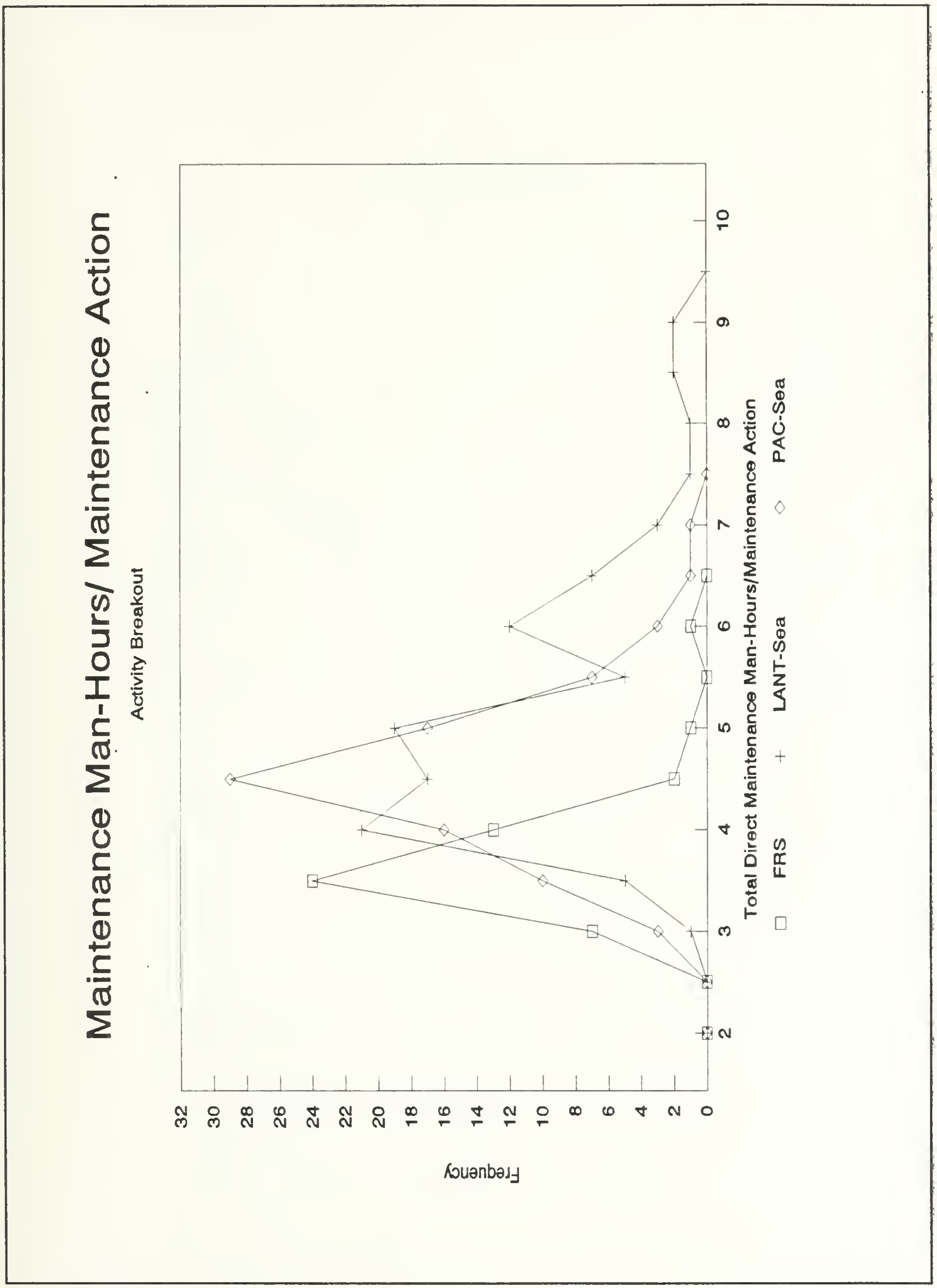

Maintenance Man-Hours/ Maintenance Action
Activity Breakout
Frequency
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
2
3
4
5
6
7
8
9
10
Total Direct Maintenance Man-Hours/Maintenance Action
FRS
LANT-Sea
PAC-Sea

Figure 72

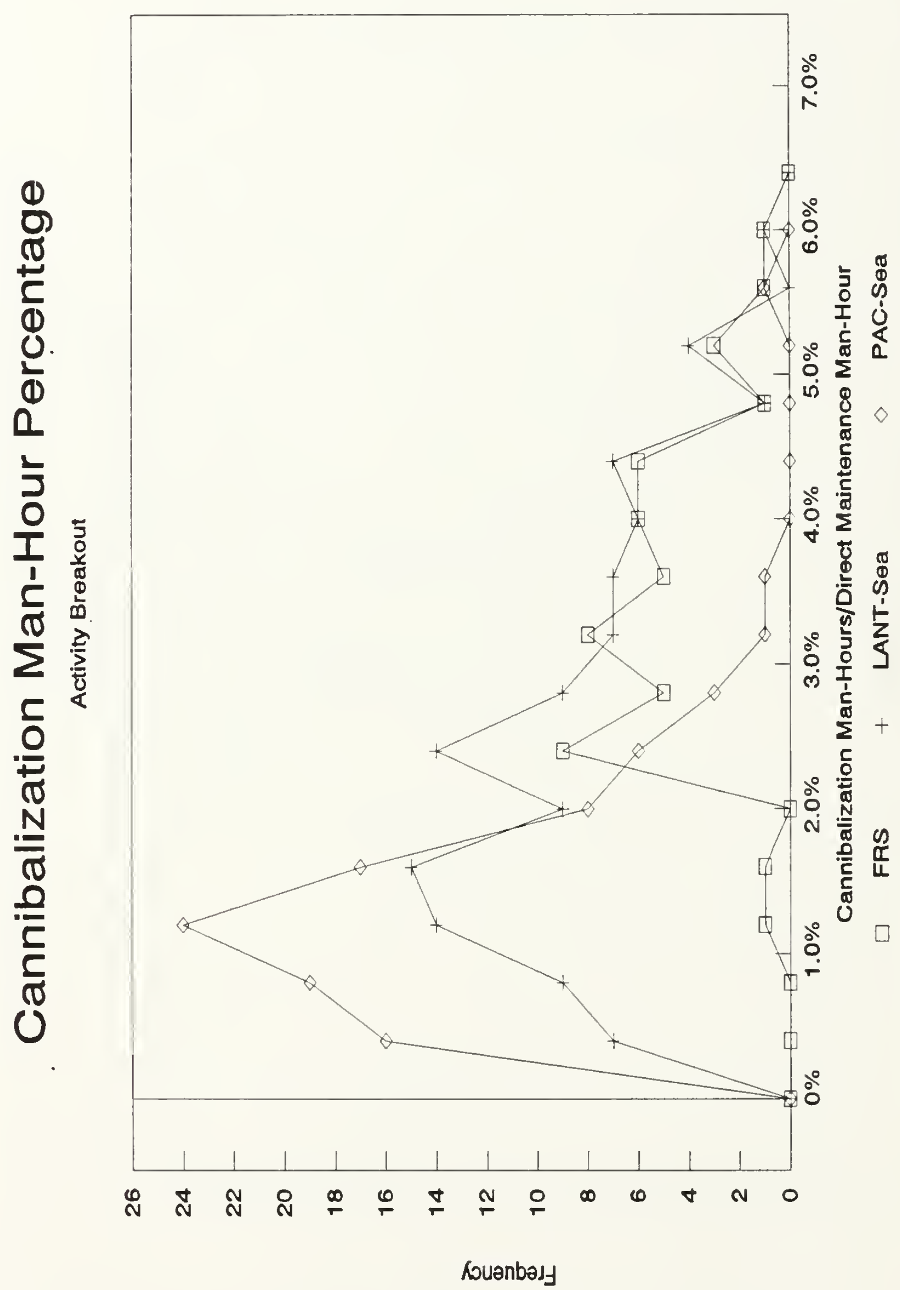

Cannibalization Man-Hour Percentage
Activity Breakout
Frequency
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
Cannibalization Man-Hours/Direct Maintenance Man-Hour
FRS
LANT-Sea
PAC-Sea

Figure 73

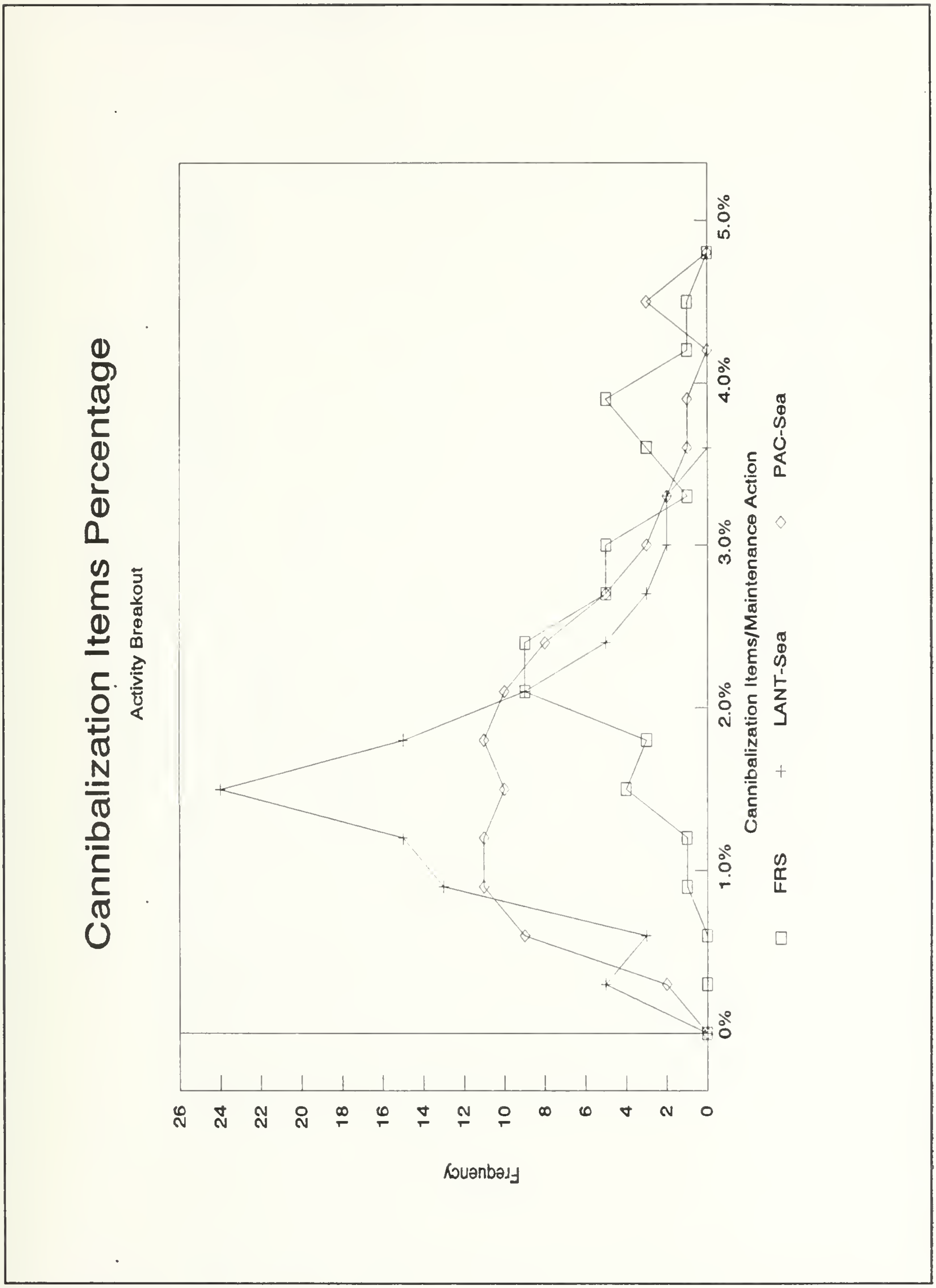

Cannibalization Items Percentage
Activity Breakout
Frequency
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0%
1.0%
2.0%
3.0%
4.0%
5.0%
Cannibalization Items/Maintenance Action
FRS
LANT-Sea
PAC-Sea

Figure 74

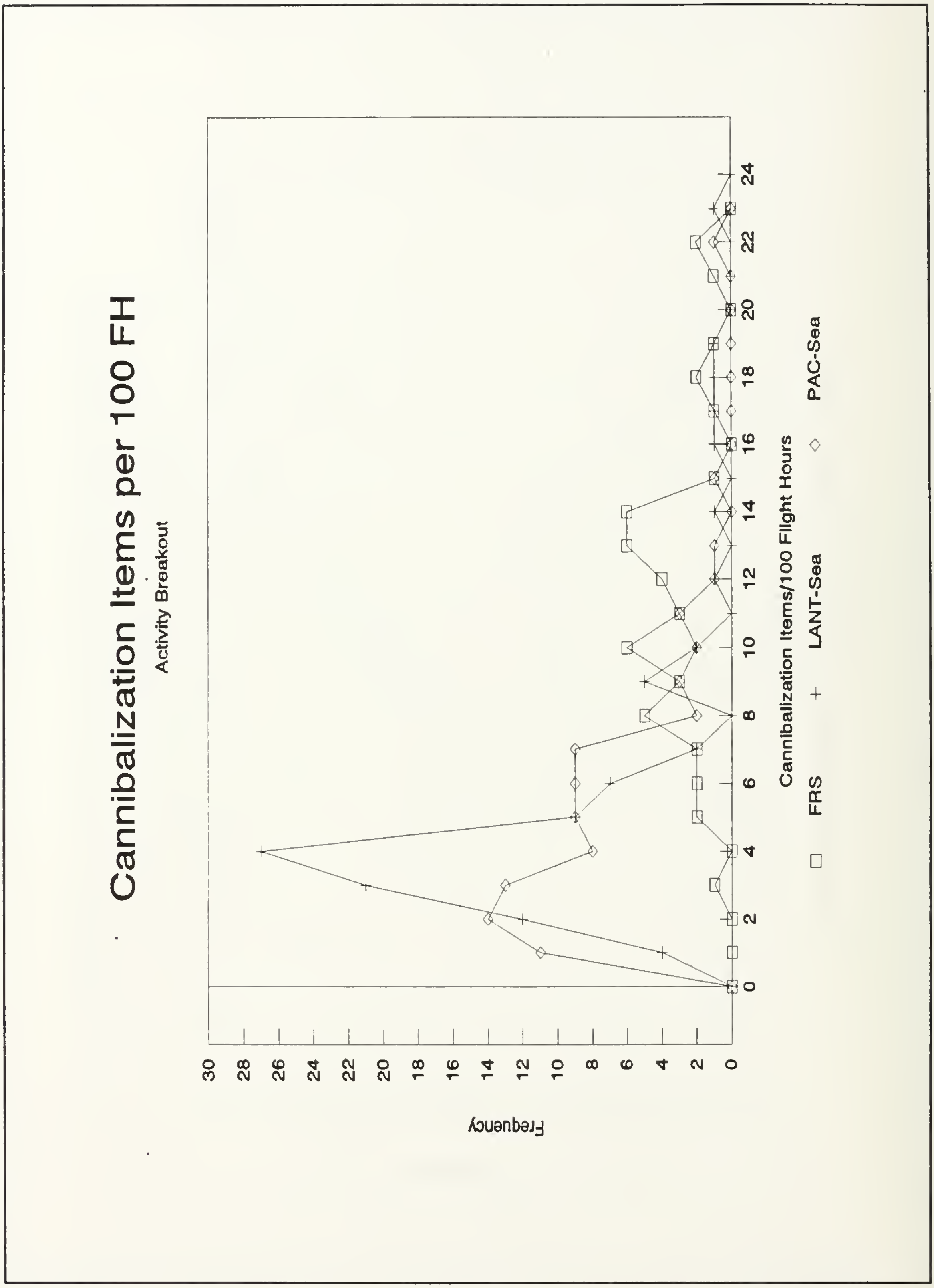

Cannibalization Items per 100 FH
Activity Breakout
Frequency
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
20
22
24
Cannibalization Items/100 Flight Hours
FRS
LANT-Sea
PAC-Sea

Figure 75

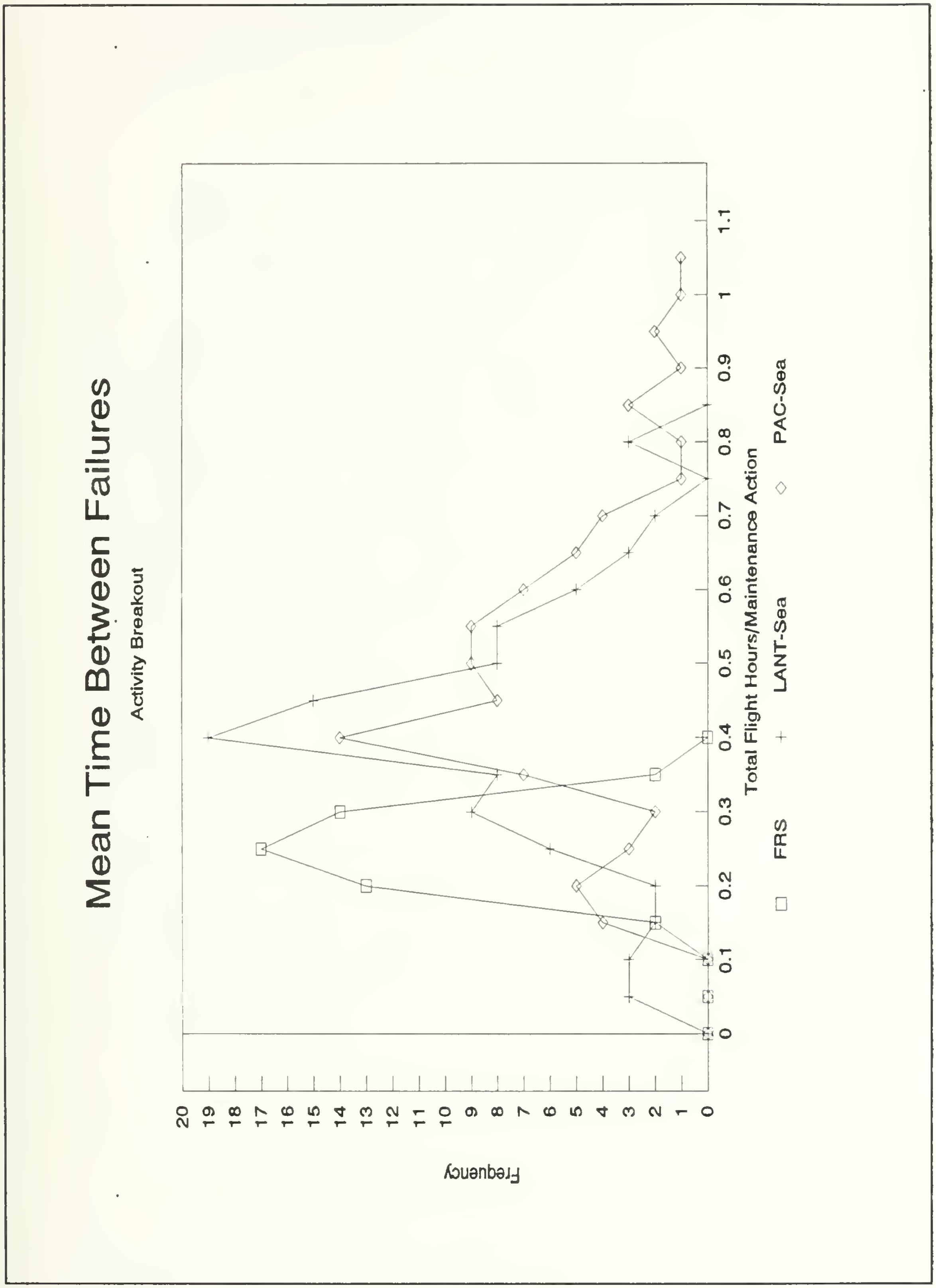
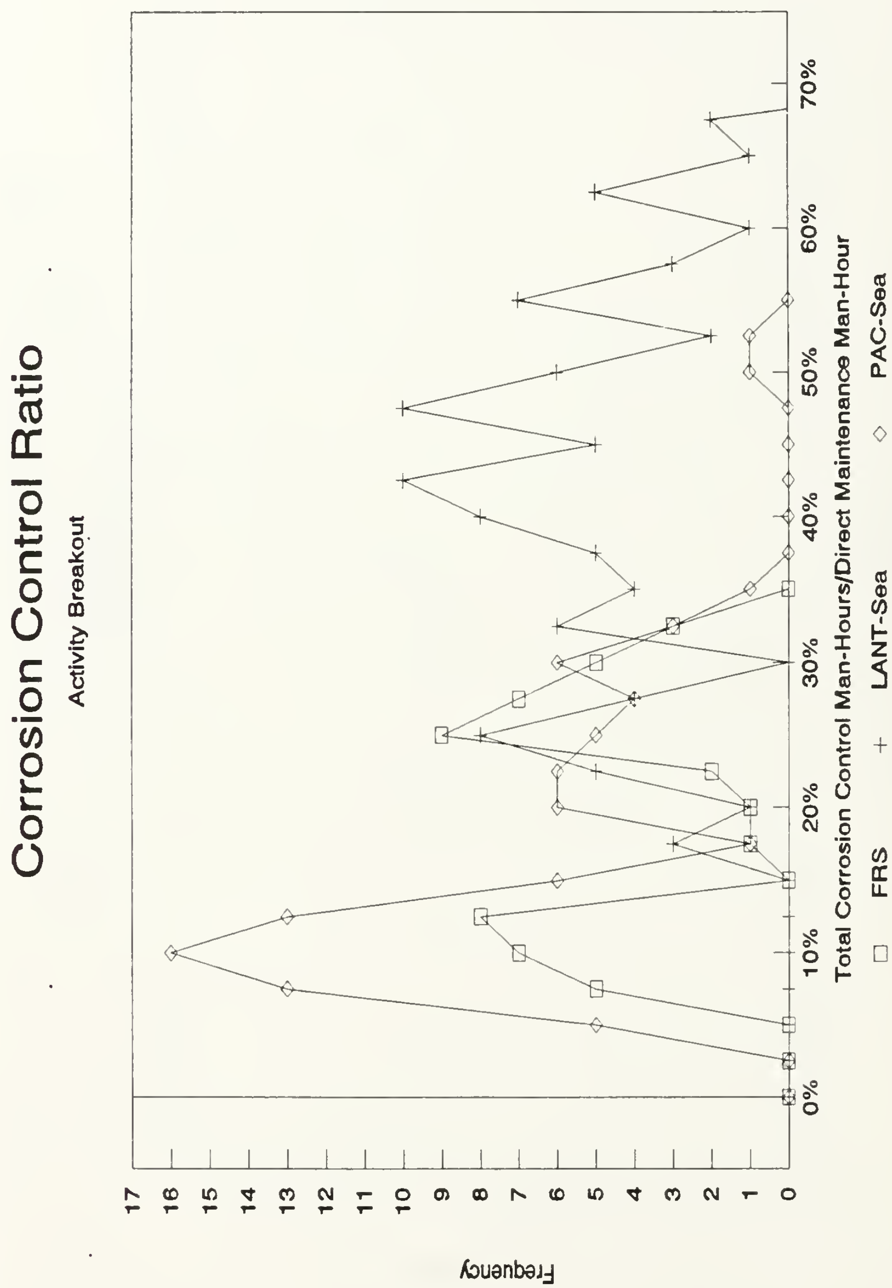

Mean Time Between Failures
Activity Breakout
Frequency
Total Flight Hours/Maintenance Action
FRS
LANT-Sea
PAC-Sea

Figure 76



Corrosion Control Ratio
Activity Breakout
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
0%
10%
20%
30%
40%
50%
60%
70%
Total Corrosion Control Man-Hours/Direct Maintenance Man-Hour
FRS
LANT-Sea
PAC-Sea

Figure 77

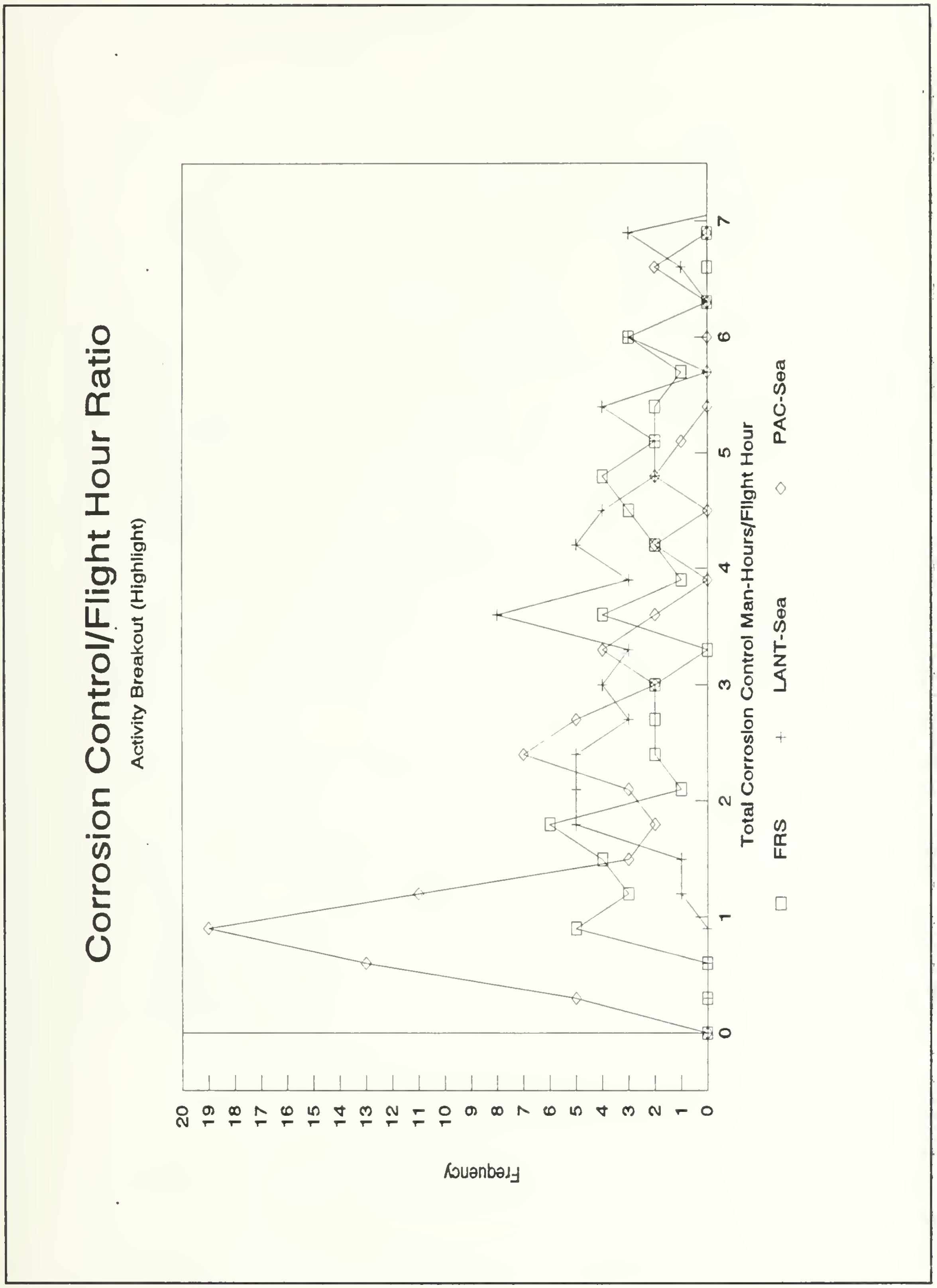
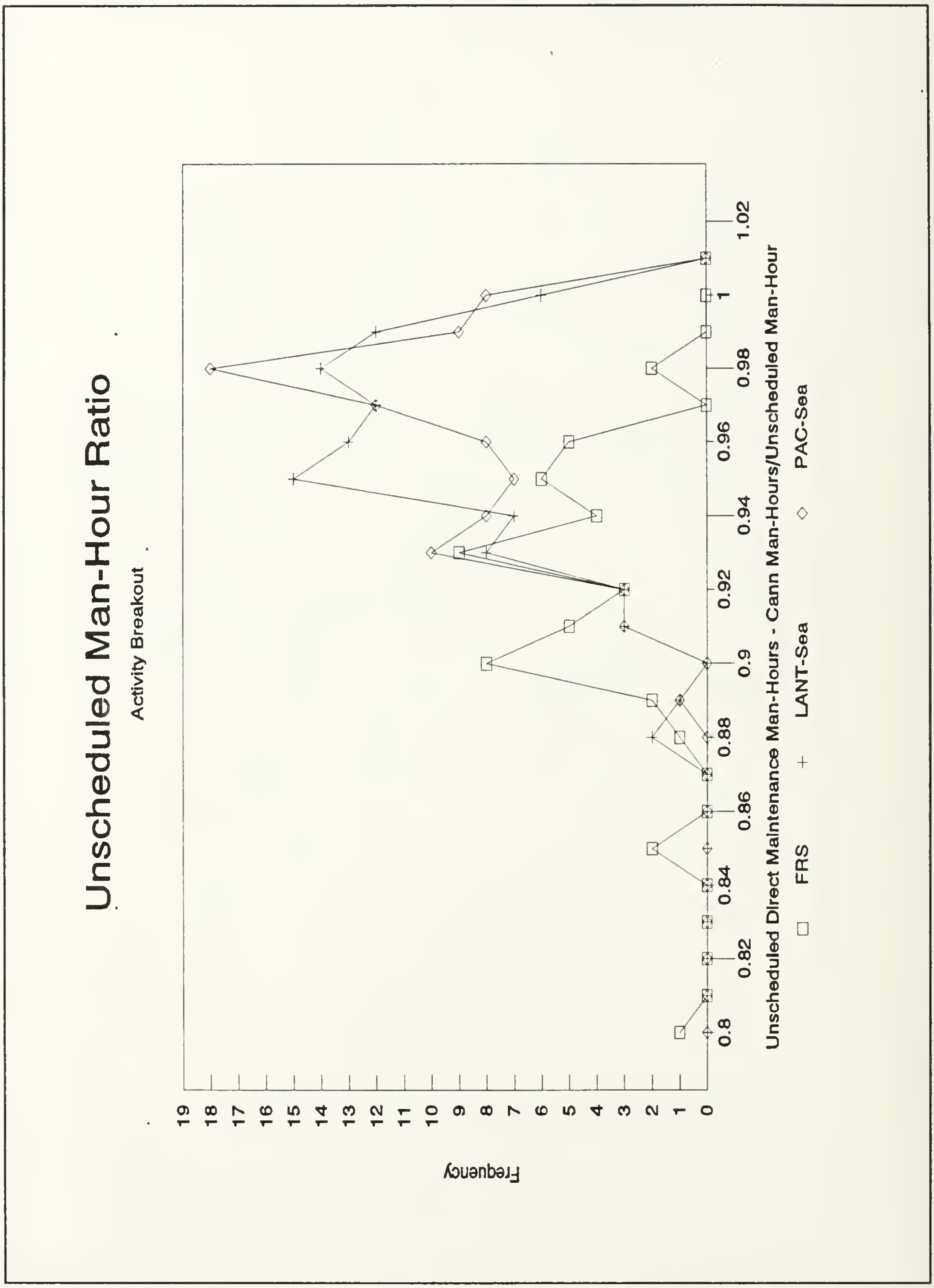

Corrosion Control/Flight Hour Ratio
Activity Breakout (Highlight)
Frequency
Total Corrosion Control Man-Hours/Flight Hour
FRS
LANT-Sea
PAC-Sea

Figure 78



Unscheduled Man-Hour Ratio
Activity Breakout
Frequency
Unscheduled Direct Maintenance Man-Hours - Cann Man-Hours/Unscheduled Man-Hour
FRS
LANT-Sea
PAC-Sea

Figure 79

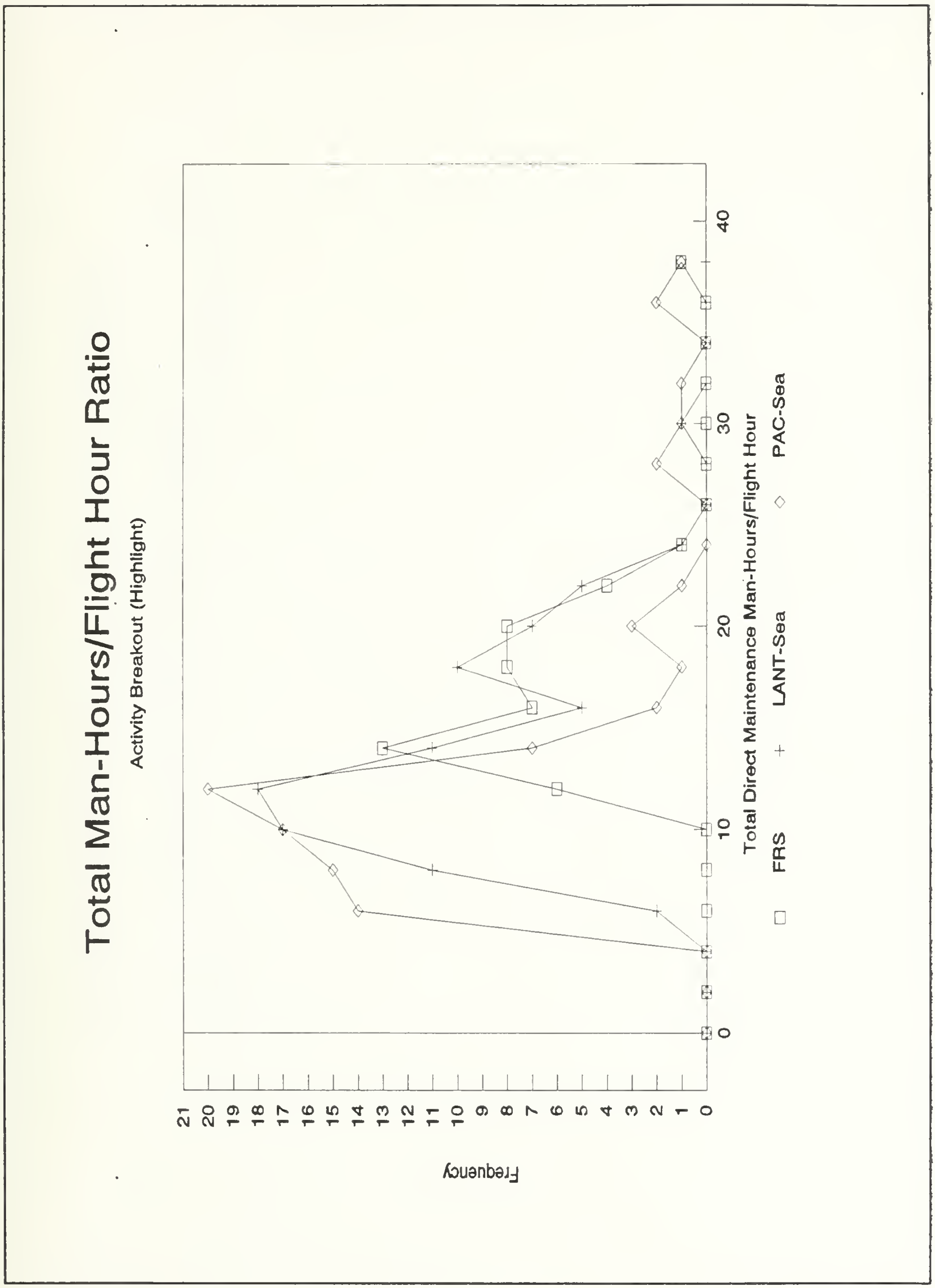

Total Man-Hours/Flight Hour Ratio
Activity Breakout (Highlight)
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
0
10
20
30
40
Total Direct Maintenance Man-Hours/Flight Hour
FRS
LANT-Sea
PAC-Sea

Figure 80

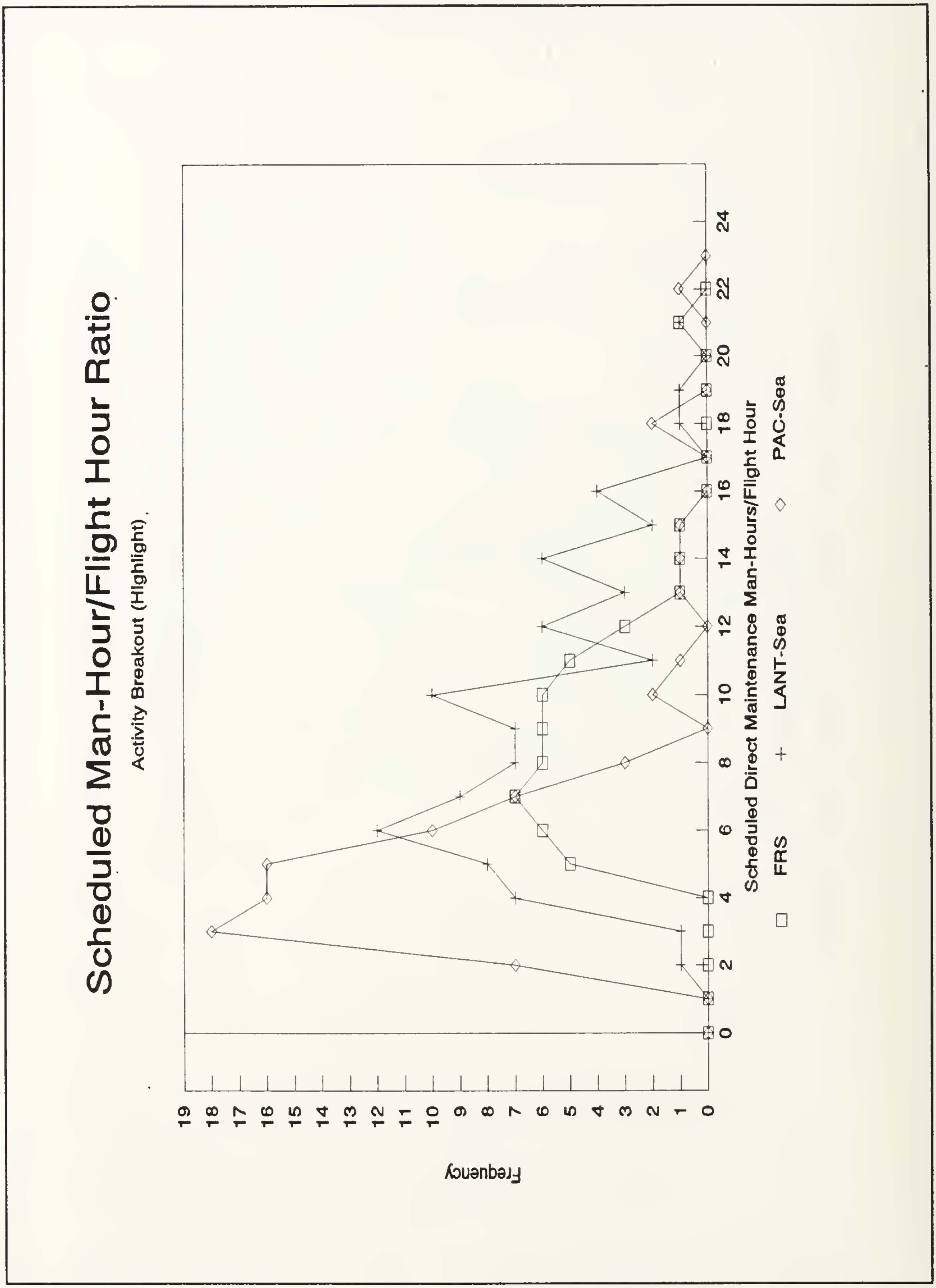
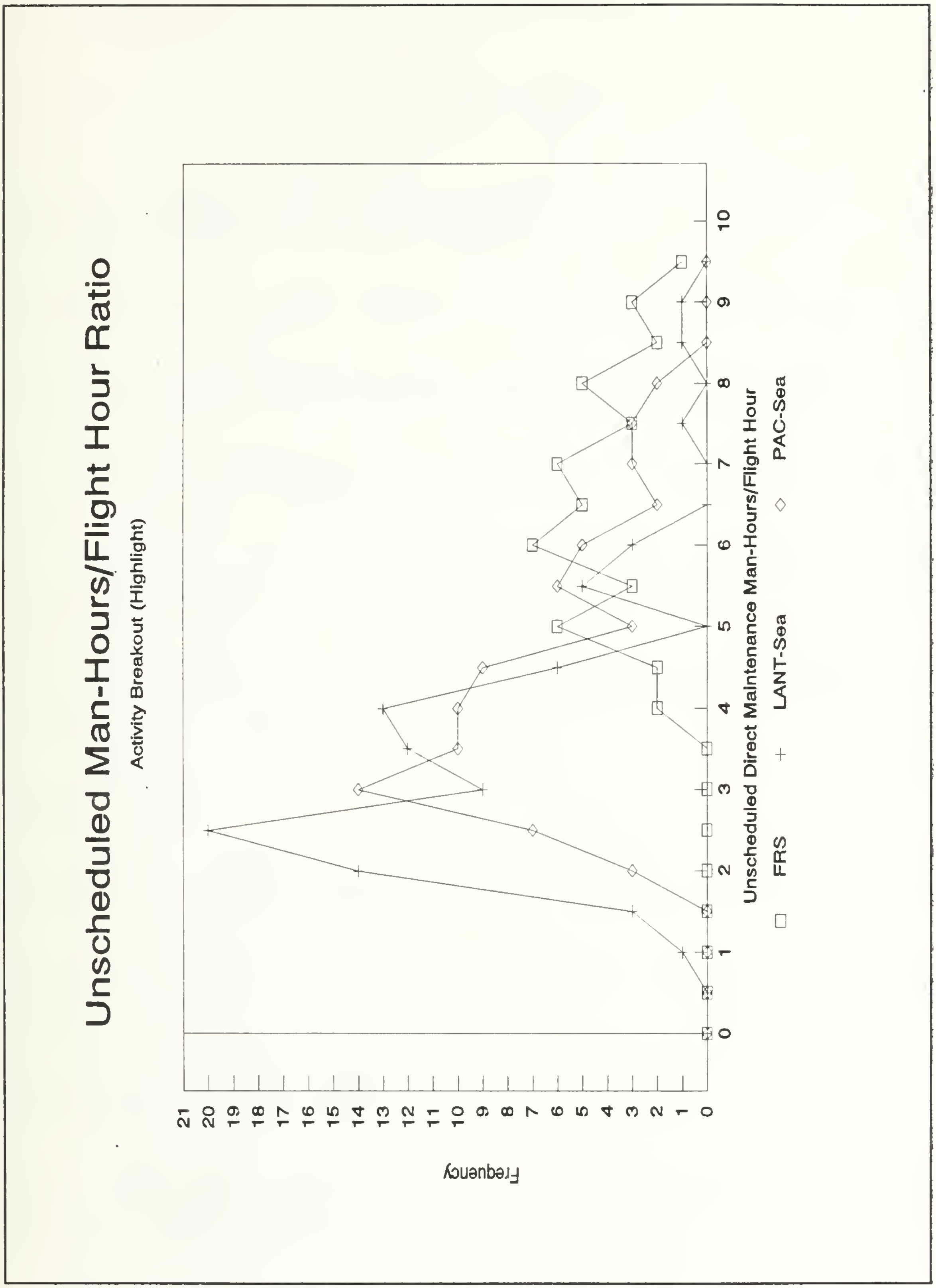
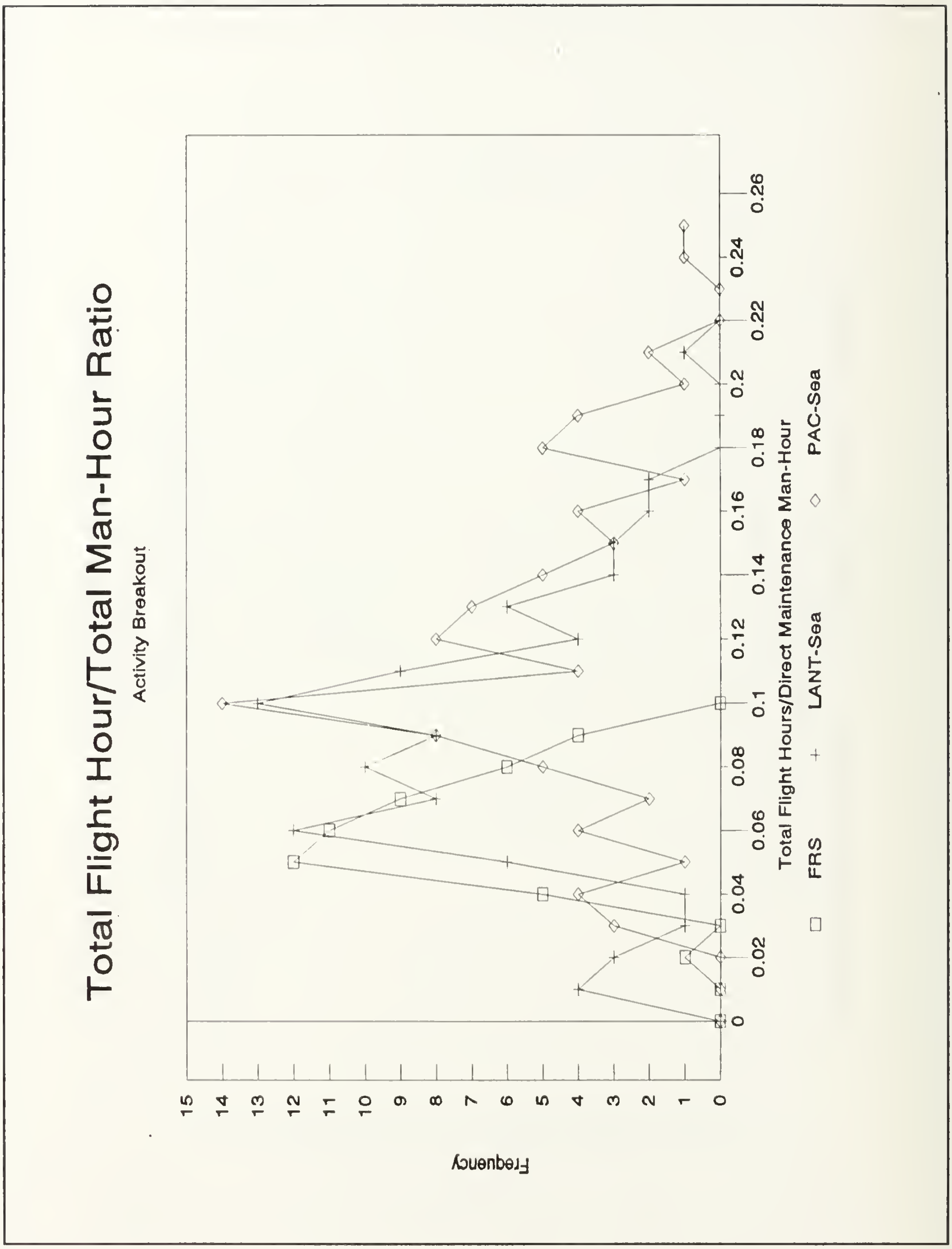

Scheduled Man-Hour/Flight Hour Ratio
Activity Breakout (Highlight)
Frequency
Scheduled Direct Maintenance Man-Hours/Flight Hour
FRS
LANT-Sea
PAC-Sea

Figure 81



Unscheduled Man-Hours/Flight Hour Ratio
Activity Breakout (Highlight)
Frequency
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
0
1
2
3
4
5
6
7
8
9
10
Unscheduled Direct Maintenance Man-Hours/Flight Hour
FRS
LANT-Sea
PAC-Sea

Figure 82



Total Flight Hour/Total Man-Hour Ratio
Activity Breakout
Frequency
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24 0.26
Total Flight Hours/Direct Maintenance Man-Hour
FRS
LANT-Sea
PAC-Sea

Figure 83

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